PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

MID-SEPTEMBER, 1960 VOL 31 NO 38

Design Digest ISSUE

The Design Digest Issue is published once each year, supplementing the weekly issues of PRODUCT ENGINEERING. This issue includes the best of the engineering data specially selected from more than 14,000 papers and articles to serve as reference material in the design, research and development of your engineered products.

GENERAL ENGINEERING **A**

METALS AND ALLOYS **B**

NONMETALLIC MATERIALS AND FINISHES **C**

FABRICATION AND PRODUCTION PROCESSES **D**

POWER TRANSMISSION **E**

MECHANICAL PARTS AND DESIGN ANALYSIS **F**

FASTENING AND JOINING **G**

MOTOR, ENGINES AND CONTROLS **H**

ELECTRICAL AND ELECTRONIC COMPONENTS **I**

HYDRAULIC AND PNEUMATIC EQUIPMENT **J**

SOURCES OF EDITORIAL

Editorial material for this Design Digest Issue was gathered from a wide assortment of publications and technical society and association papers. While not every publication or technical society listed below is represented in this current issue, each helped considerably in providing a background of engineering trends and developments in their fields.

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New York 16, New York

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Institute of the Aerospace Sciences
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ALLIS-CHALMERS ELECTRICAL REVIEW
Allis-Chalmers Mfg. Co.
Milwaukee 1, Wisconsin

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33 West 39 Street, New York 18, N. Y.

JOURNAL OF APPLIED MECHANICS
American Society of Mechanical Engineers
29 West 39 Street
New York 18, New York

JOURNAL OF APPLIED PHYSICS
American Institute of Physics
335 East 45 Street
New York 17, New York

ASTM BULLETIN
American Society for Testing Materials
1916 Race Street, Philadelphia 3, Pa.

BELL LABORATORIES RECORD
Bell Telephone Laboratories
463 West Street, New York 14, N. Y.

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CORROSION
National Association of Corrosion Engineers
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New York 7, New York

JOURNAL OF ENGINEERING EDUCATION
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Ford Instrument Company
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Long Island City 1, New York

ENGINEERING MATERIALS AND DESIGN
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London, W.C. 2, England

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P. O. Box 2583
Grand Central Station
New York 17, New York

FRONTIER
Armour Research Foundation
10 West 35 Street
Chicago 16, Illinois

GM ENGINEERING JOURNAL
Educational Relations Section
Public Relations Staff
General Motors Technical Center
Warren, Michigan

GRAY IRON NEWS
Gray Iron Founders' Society
210 National City, E. 6th Building
Cleveland 14, Ohio

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A McGRAW-HILL PUBLICATION

Mid-September, 1960

Vol. 31, No. 38

Executive, Editorial, Circulation and Advertising Offices:
330 West 42nd St., New York 36, N. Y.
Telephone: LOngacre 4-3000
Teletype: TWX NY 1-1636
Cable Address: MCGRAW-HILL, NY

PRODUCT ENGINEERING is published weekly — with an additional Design Digest Issue in Mid-September, by McGraw-Hill Publishing Company, Inc. James H. McGraw (1860-1948), founder. US subscription rates for individuals in the field of the publication, $3 per year; single copies 50 cents (including this issue); Canadian subscriptions $5 per year; foreign $25 per year. Payable in advance. Printed in Albany, NY; second-class postage paid at Albany, NY. Title ® registered at US Patent Office.

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POSTMASTER: Please send form 3579 to Fulfillment Manager, PRODUCT ENGINEERING, 330 W. 42nd St., New York 36, N.Y.

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INCO MAGAZINE
International Nickel Co., Inc.
67 Wall Street
New York 5, New York

INSTRUMENTATION
Minneapolis-Honeywell Regulator Co.
Wayne and Windrim Avenues
Philadelphia 44, Pa.

INSTRUMENTS AND CONTROL SYSTEMS
845 Ridge Avenue
Pittsburgh 12, Pennsylvania

IRON & STEEL ENGINEER
Association of Iron and Steel Engineers
1010 Empire Bldg.
Pittsburgh 22, Pa.

LUBRICATION ENGINEERING
American Society of Lubrication Engineers
5 No. Wabash St.
Chicago, Illinois

METALWORKING PRODUCTION
McGraw-Hill Publishing Co., Ltd.
95 Farringdon Street
London, E.C. 4, England

THE MAGAZINE OF MAGNESIUM
Brook & Perkins
1950 West Fort Street
Detroit 16, Michigan

THE MAINSPRING
Associated Spring Corporation
Bristol, Connecticut

MECHANICAL ENGINEERING
American Society of Mechanical Engineers
29 West 39th Street
New York 18, New York

MECHANICAL WORLD & ENGINEERING RECORD
31 King Street, West
Manchester 3, England

METAL PROGRESS
American Society for Metals
Metals Park
Novelty, Ohio

JOURNAL OF METALS
American Institute of Mining, Metallurgical and Petroleum Engineers
29 West 39 Street
New York 18, New York

MODERN CASTINGS
American Foundryman's Society
Golf & Wolf Roads
Des Plaines, Illinois

MODERN MACHINE SHOP
Gardner Publications
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JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS
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Washington 5, D. C.

NLGI SPOKESMAN
4638 J. C. Nichols Parkway
Kansas City 12, Missouri

ORDNANCE
American Ordnance Association
708 Mills Building
Washington 6, D. C.

PLASTICS
Bowling Green Lane
London, E. C. 1

PLATING
American Electroplaters' Society
445 Broad Street
Newark 2, New Jersey

SAE JOURNAL
Society of Automotive Engineers
485 Lexington Avenue
New York 17, New York

SPE JOURNAL
Society of Plastics Engineers
65 Prospect Street
Stamford, Connecticut

SPERRY ENGINEERING REVIEW
Sperry Gyroscope Co.
Div. of Sperry Rand Corp.
Great Neck, New York

THE MAGAZINE OF STANDARDS
American Standards Association
10 E 40 Street
New York 16, New York

TECHNICAL JOURNAL
American Telephone & Telegraph Company
195 Broadway
New York 7, New York

TECHNICAL NOTES
National Advisory Committee for Aeronautics
Washington, D. C.

THE TOOL ENGINEER
American Society of Tool Engineers
10700 Puritan Avenue
Detroit 38, Michigan

WELDING JOURNAL
American Welding Society
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National Electronics Conference
National Lubricating Grease Institute
National Metal Exposition Congress
Pressed Metal Institute
Society of Automotive Engineers
Society for Experimental Stress Analysis
Society of Plastics Engineers
Society of the Plastics Industry
Westinghouse Machine Tool Forum

EDITORIAL CONTENT

SECTION A GENERAL ENGINEERING . . .

Design Abstracts 26
Copying Methods for the Engineering Office 28
Ten Commandments for Design Reliability *by B. Bradford Richardson* 30
Noisy Sound *by Myron M. Kawa, Jr.* 32
Tabulated: Test-chamber Refrigerants *by Dale J. Missimer* 34
Basic Information on Air Filtration 35
When Plastics Burn What Are the Hazards from Toxic Fumes? *by E. H. Coleman* 40

SECTION B METALS AND ALLOYS . . .

Design Abstracts 58
A Look at Copper Corrosion 60
Cross-reference Charts for Die-casting Alloys 63
Austenitic "Cold Working" for Ultra-strength Steel *by D. J. Schmatz, J. C. Shyne and V. F. Zackay* 64
For High Temperatures These Metals for Magnets 67
Chemical Resistance of Zirconium, Titanium, Tantalum and 316-Stainless Steel 68
Spring Material at High Temperature 69
Beryllium—What It Can Do and How It Can Be Worked 70

SECTION C NONMETALLIC MATERIALS AND FINISHES . . .

Design Abstracts 104
Refractory Materials Today 106
Designing for Simpler Metal Finishing Techniques *by Adrian Walmsley* 108
Quick Facts About Porcelain Enamel 112
9 Plastic Foams *by C. R. Davall* 113
Lignum Vitae—A Unique Engineering Material 115
Plating Nickel on Aluminum Alloys *by James T. N. Atkinson* 118

SECTION D FABRICATION AND PRODUCTION PROCESSES . . .

Design Abstracts 162
9 Heat-forming Techniques for Plastic Sheet *by R. E. Kostur* 164
9 Typical Coil Designs for Induction Soldering and Brazing 168
12 Ways to Work Titanium *by J. M. Wentzell* 169
Matching the Burner to the Job is Key to Better Flame Hardening *by B. G. Ward, Jr.* 171
Design Hints on Electroforming *by Bruce Chandler Jones* 174

SECTION E POWER TRANSMISSION . . .

Design Abstracts 200
6 Flexible Shaft-couplings *by R. Waring-Brown* 202
Surveyed: 10 Lubrication Methods *by Allen F. Brewer* 205
Belt Friction and Shaft Load *by O. R. Fendrich* 208
Shot Peening in Gear Design *by J. C. Straub* 210
6 Applications for the Capstan-type Power Amplifier *by L. A. Zahorsky* 213

for design digest issue

SECTION F MECHANICAL PARTS AND DESIGN ANALYSIS . . .

Design Abstracts 270
Design Curves for Journal Bearings *by Donald F. Hays* 272
New Concepts on Safety Factors *by Charles Lipson* 275
Which Bearing and Why? *by Arnold O. DeHart* 279
Moment of Inertia of Cylinders 285
Design Equations for Curved Springs *by Joachim Palm and Klaus Thomas* 286
Designing Products for Automatic Assembly *by Robert L. Esken* 288

SECTION G FASTENING AND JOINING . . .

Design Abstracts 336
How to Design for Blind Riveting *by Charles E. Heilig, Jr.* 338
How Rings Aid Design *by Howard Roberts* 343
Fastener Torque: How Much? *by John A. Stevenson* 346
18 Ways to Join Honeycomb Panels *by Frank J. Filippi and Boris Levenetz* 348

SECTION H MOTORS, ENGINES AND CONTROLS . . .

Design Abstracts 386
Flexible Engine-suspensions 388
How to Control Speed of Fhp Motors 390
Correcting Motor Power-factor *by G. R. Brooks* 392
Operating Principles of 13 Timing Devices *by John C. Ponstingl* 393
5 Clutches for Servomechanisms *by Kenneth W. Kohlmeyer* 396
Dynamic Response of Remote Pressure Pickups *by Robert J. Reid and Edward M. Kops* 401

SECTION I ELECTRICAL AND ELECTRONIC COMPONENTS . . .

Design Abstracts 430
10 X-ray Methods *by Vern W. Palen* 432
How Information is Presented on Cathode-ray Display Tubes *by Richard A. Barker* 434
Fundamentals of Slip-ring Assemblies 439
For Inspection and Decision Making, Electronic Gaging *by David R. Houck* 440
16 Ways to Apply Limit Switches 442
Semiconductors Compared 445

SECTION J HYDRAULIC AND PNEUMATIC EQUIPMENT . . .

Design Abstracts 492
16 Ways to Mount Hydraulic Cylinders 494
How to Classify Fluids by Viscosity *by R. A. Minard* 495
Gas Nomograph for Converting to Standard Cubic Feet *by F. Caplan* 497
Reducing Leakage from Hydraulic Systems *by R. Q. Sharpe* 498
7 Relief Valves for Portable Equipment *by C. A. L. Ruhl* 502
15 Jobs for Pneumatic Power 506

EDITORIAL SUBJECT INDEX

—A—

Agitation of liquids 507
Air, cooling and heating 507
  filtration of 35–39
  standard volume of 497
Alloys, die-casting 63
  (*see also alloy in question*)
Alnico 67
Aluminum-base alloys 63
Aluminum, plating techniques ... 111, 118, 119
Assembly, automatic 288, 289
Atomizing liquids 507
Austenitic "cold working" 64–66
Automatic assembly 288, 289

—B—

Barrel tumbling 108
Bearings, how to choose 279–284
  journal, design curves for 272–274
Belt friction 208, 209
Beryllium 70–73
Billow forming 166
Blind riveting 338–342
Blow-up vacuum reverse 166, 167
Blueprinting 28, 29
Bolt, compressor, design of 277, 278
Borides, as refractory materials ... 106, 107
Broaching, nonlinear 214
Brownprinting 28, 29

—C—

Cable, pressurizing of 507
Capacitor charge and discharge timer 395
Capacitor motors 391
Capstan-type power amplifier 213, 215
Carbides, as refractory materials .. 106, 107
Carbon, in steel 66
Carbon steel 67
Cathode-ray display tubes 434–438
Cellulose-acetate foam 114
Cermets 106, 107
Chemicals, corrosive 68
Chrome silicon 69
Chrome vanadium 69
Clutches for servos 396–400
Coatings, diffusion 106
  silicide 107
Coercive force, Oresteds 67
Cold-worked steel 64–66
Combustion, support of 507
Compressor bolt, design of 277, 278
Conveying solids 507
Cooling air 507
Copper-base alloys 63
Copper, corrosion of 60–62
  in electroforming 176, 177
Copying methods, office 28, 29
Corrosion of Admiralty metal 61
  aluminum brass 62
  copper 60–62
  Muntz metal 61
  yellow brass 61
Corrosive chemicals 68
Counting, remote 215
Couplings, shaft, flexible 202–204
Curie points 67
Curved springs, equations for 286, 287
Cylinders, hydraulic 494
Cylinders, moment of inertia 285

—D—

Dashpot timer 394
De-aerating of liquids 507
Deposit corrosion 60, 61
Deposit rate in electroforming 176
Dezincification 60
Diazo copying 28, 29
Die-casting alloys 63
Difference computer 440, 441
Differential valves 503, 504
Diffusion coatings 106
Diffusion transfer copying 28, 29
Display tubes, cathode ray 434–438
Dog coupling 202, 203
Drape forming 164, 165
Dry ice 34
Dye transfer copying 28, 29

—E—

Eccentricity ratio, of bearing 272–274
Eddy-current clutch 398, 399
Elastomeric mountings 389
Electro-chemical polishing 108
Electrofax 28, 29
Electroforming 174–177
Electronic gaging 440, 441
Electronic timer 395
Electroplating 109–111
Electrostatic copying 28, 29
Enamel, porcelain 112
Engine suspensions 388, 389
Engine vibrations 388
Epoxy foam 114
Escapement timer 395

—F—

Factor of safety 275–278
Fastener torque 346, 347
Fastening in automatic assembly 289
Fatigue strength, in gears 211
Fhp motors, speed control of 390, 391
Filtration, air 35–39
Finishes, in automatic assembly 289
Finishing techniques, metal 108–111
Flame hardening 171–173
Flexible suspensions 388, 389
Fluctuating stress 276–278
Fluid viscosity 495, 496
Fluoroscopy, industrial 432
Flux density, magnetic 67
Foams, plastic 113, 114
Forming, vacuum 164, 506
Friction, in belts 208, 209
  (*see also material in question*)
Friction-disc clutch 396, 397
Fumes, toxic, from plastics 40, 41

—G—

Gage circuit 440, 441
Gaging, electronic 440, 441
Galvanic corrosion 62
Gas sampling 506
Gas, standard volume 497
Gaskets, for hydraulic systems 501
Gears, fatigue strength gain 211
  flame hardening of 173
  shot peening of 210
Goodman diagram 278
Governor-controlled motors 391
Graphite, as a refractory material .. 106, 107

—H—

Heat forming, of plastic sheet 164–167
Heat transfer copying 28, 29
High-temperature materials 106, 107
Honeycomb panels, joining of 348–351
Hoppers, in automatic assembly 288
Hoses 501
Hydraulic cylinders 494
Hydraulic systems, leakage from .. 498–501
Hysteresis clutch 397, 398

—I—

Impingement corrosion 60, 61
Inconel 69
Indalloy 67
Induction disc timer 395
Induction-motor power-factor 392
Induction soldering 168
Inductive buildup timer 395
Inertia timer 395
Intermetallic compounds 107
Inverted differential valve 504

—J—

Journal bearings, design of 272–274

—L—

Laminated spring coupling 203
Leakage, hydraulic, reduction of .. 498–501
Leak testing 507
Lignum vitae, properties of 115–117
Limit switches 442–444
Liquid nitrogen 34
Liquids, agitation of 507
Load positioning 214
Lubrication, methods of 205–207
Lubrication film in bearings 272–274

—M—

Magnesium, comparison with beryllium 70–73
Magnesium-base alloys 63
Magnet metals 67

for design digest issue

Magnetic fluid clutch 400
Magnetic particle clutch 399, 400
Magnetic remanence 67
Mandrels, in electroforming 176, 177
Maple, friction of 116
Martensite, in steel 64, 65
Mercury timer 395
Metal-finishing 108–111
Metering, remote 215
Micarta, friction of 116
Microfilm copying 29
Molybdenum, alloys 106, 107
Molybdenum silicide 107
Moment of inertia 285
Motor power factor 392
Motors, fhp, speed control of 390, 391
Mountings, elastomeric 389
Multi-spring coupling 204

—N—

Newtonian fluids 495, 496
Nickel plating, general 108–111
in electroforming 176, 177
on aluminum 118, 119
Ni-span "C" 69
Nitrides, as refractory materials ..106, 107
Nitrogen, liquid 34
Noisy sound 32, 33
Non-Newtonian fluids 495, 496
Nylon, friction of 116

—O—

Oresteds, coercive force 67
O-ring action 500
Out-of-balance forces, in engines ..388, 389
Oxidation resistance 107, 108

—P—

Packing, hydraulic 501
Paint protection, of metals 111
Panels, honeycomb, joining of ...348–351
Parock (rubber), friction of 116
Parts, feeding, holding etc 288, 506
Phenolic foam 113
Phosphate films, on metal 110
Photocopying 28, 29
Pickups, remote pressure 401
Pilot-operated valves 504, 505
Pitting of copper 60, 61
Plastics (*see plastic in question*)
burning, fumes from 40, 41
foams of various 113, 114
heat-forming of 164–167
Plug assist, in heat forming 165
Pneumatic power, jobs for 506, 507
Pneumatic timer 394
Polishing, electro-chemical 108
Polyethylene foam 114
Polystyrene foam 113, 114
Poppet valves 502, 503
Porcelain enamel 112
Portable equipment, valves for ...502–505
Power amplifier, mechanical 213–215
Power factor, of induction motors ... 392
Precious metal, plating with 111
"Prefabricated" foam 113
Pressure forming of plastic sheet 167
Pressure pickups 401
Pressurizing of cable 507

—Q—

Quad rings 501

—R—

Radiography, industrial 432
Refractory materials 106, 107
Refrigeration, test chambers 34
Reinforced metals 106
Reliability, in design 30, 31
Relief valves 502–505
Remalloy 67
Remanence, magnetic 67
Remote metering and counting 215
Rhodium 107
Rings, snap 343–345
Riveting, blind 338–342
Routing, irregular 215

—S—

Safety factors 275–278
Seals, hydraulic 501
Season cracking 60–62
Selective fitting 289
Semiconductors 507
Sensing element 440, 441
Series motors 390
Servomechanisms, clutches for 396–400
Shaft-couplings, flexible 202
Shaft loads in belt drives 208, 209
Shot peening of gears 210–212
Shunt motors 390, 391
Silicides as refractory materials ..106, 107
Silicone foam 114
Slip casting 107
Slip-ring assemblies 439
Snap-acting switches 442–444
Snap rings in design 343–345
Solder, in electroforming 175
Soldering, induction 168
Sound levels 32, 33
Spinels, definition of 107
Spring materials, relaxation of 69
Spring-pin coupling 204
Springs, curved, equations for ...286, 287
Stainless-steel, chemical resistance of. 68
Steel, carbon 67
effect of carbon in 66
martensite in 64, 65
oil tempered 69
spring 69
stainless, chemical resistance of 68
17-7 ph 69
18-8 69
316 68
tungsten 66
ultra-strength 64–66
Steel-plated beryllium 70–73
Stress, fluctuating 276, 277
in gears 211
in springs 286, 287
preload 276, 277
significant 275
Stress-corrosion 60–62
Stress-relief annealing 62
Sulfides, as refractory materials ..106, 107
Sum computer 440, 441
Switches, limit 504–506

—T—

Tantalum, chemical resistance of 68
Tensile testing machine, control of ... 214
Test-chamber refrigerants 34
Thermal timer 394
Thixotropic fluids 495, 496
Timing devices, operation of 393
Titanium, chemical resistance of 68
how to work it 169, 170
Titanium carbide 106, 107
Torque of fasteners 346, 347
Torque booster 213–215
Tumbling, barrel 108
in automatic assembly 289
Tungsten steel 67

—U—

Ultra-strength steel 64–66
Urethane foam 113, 114

—V—

Vacuum forming 506
Vacuum snap back 165
Valves, relief 502–505
Vibrations, engine 388
Vinyl foam 113, 114
Viscosity 495, 496
V-ring dimensions 499

—W—

Winch control 214
Wiper rings 499
Wobbler coupling 202

—X—

X-ray methods 494, 495
Xerography 28, 29

—Z—

Zinc-base alloys 63
Zirconium 68

Editorial Subject Index for Previous Design Digest Issues

Prefix number before the section letter and page number indicates the issue. 7 is the DESIGN DIGEST ISSUE, published Mid-September, 1958. 8 is the DESIGN DIGEST ISSUE, published Mid-September, 1959.

— A —

Acetal plastics, properties of.....7 C11
Acetate butyrate, forming of.....7 D6
Acrylic rubber, properties of.....8 113
Ac transformers, for arc welding...8 172
Actuators, hydraulic, resonant frequency of.....7 J5
Adjustable-speed drives.....8 428
Air bearings, flat.....8 288
Air circuits, assembly of.....8 530
design of.....8 538
Air-relief hole, in electroplating....8 124
AISI, type numbers for stainless steel.....8 75
Alignment nomograms.....8 26
Alloy-junction transistor.....8 472
Alloys, aluminum.....7 B6
magnesium, treatment of.....7 C4
steel, precipitation hardening...7 B9
spring material.....7 B12
titanium.....7 B2
to combat corrosion.....7 B16
Aluminum, high strength alloys...7 B6
soldering of.....8 372
Aluminum-alloy structures.....8 298
Annual reports, what it tells.....8 30
Applications of, compressors, heavy duty.....7 J12
gaskets.....7 F3
plastic joining.....7 G5
plastic piston rings.....7 F9
rectifiers.....7 I3
solar furnaces.....7 A14
spring materials.....7 B12
thermistors.....7 I16
thermoplastic forming.....7 D6
ultrasonic machining.....7 D13
ultra-strength steel.....7 B15
Arc-welding, power sources for....8 172
Asbestos, effects of medium on....7 C9
friction materials.....7 C16
Austenitic steel.....8 74

— B —

Backstopping clutches.....7 E18
Bearings, air, damage to.....8 476
design data for.....8 288
damage, float coupling.....7 E7
heat and dissipation.....7 F10
loads, plastic belting.....7 E10
Belt and wire rope drives.....7 E10
Belts, chains, gears, comparison of.8 210
Belts, flat.....7 E10
plastic-core leather.....7 E14
V-drives.....7 E9
Bending of circular plates.....8 296
Beryllium.....8 68
Binder for coatings.....7 D10
Bolt and rivet joints for joining tubing.....7 G12
Bolts, steel, markings for.....7 G17
Brazed honeycomb sandwich.....8 375
Brazing, dissimilar metals.....8 365
ph steels.....7 B10
Brittle coatings, in stress analysis..8 302
Buna-N, effects of medium on....7 C8
Buna-S, properties of.....8 112
Butyl (GR-1), properties of.....8 113

— C —

Cam-controlled valves.....8 532
Cast iron, machinability of.....8 66
Castings, ductile iron.....8 67
pearlitic malleable.....7 D7
Catenary effect, belt drives.....7 E13
Cellulose acetate, forming of.....7 D6
properties.....7 C11
Ceramic materials.....8 118
Ceramics, friction materials.....7 C16
Chains, belts, gears, comparison of 8 211
Chemistry of ph steels.....7 B8
Chlorinated polyether.....7 C11
Chlorotrifluoroethylene.....7 C11
Chromium.....8 68
plating, designing for.....8 124
Circuits, air.....8 530, 538
fluid, trouble shooting.....7 J15
fluid power.....8 542
designs of.....8 538
hydraulic.....8 539
liquid-level detectors.....8 534
servomotor.....8 421
transistor, photosensitive.....8 473
tetrode.....8 472
Clutch, dry, torque in.....8 300
eddy-current.....8 431
sprag-type.....7 E18
Coatings, conductive and resistive.7 D8
porcelain enamel.....7 C2
see also Finishes
Cobalt-bearing alloys.....7 B16
Cold heading.....8 74
Columbium.....8 68
Combined air-control circuits.....8 531
Comparators, optical.....7 A5
Compatibility, of elastomers with hydraulic fluids.....8 535
Components, identification of.....8 34
Compression joints for joining tubing.....7 G14
Compressors, heavy-duty.....7 J12
nonlubricated.....7 F7
Conductive and resistive coatings..7 D8
Concentration cell.....8 63
Constant purge system for density.....8 37
for liquid level.....8 37
Continuous liquid-level recorders..8 534
Control accessories, air circuit, location of.....8 531
Control devices, selecting for human operators.....8 39
Conveyor-belt wire.....8 74
Copper-oxide rectifiers.....7 I3
Corporate report, what it tells....8 47
Corrosion, alloys to combat.....7 B16
resistance to.....8 62
wrought iron.....7 B5
Cotton belt formulas.....7 E11
Couplings, fluid, operation.....7 E15
limited end float.....7 E6
Creep, titanium.....7 B2
CSA standards for punch press operation.....7 H6
Curve fitting.....7 A15

— D —

Dc motor-generator, for arc welding.....8 172
Dc relays, sensitive.....7 I8
Dc transformer-rectifier, for arc welding.....8 172
Deep draws, electroplating of.....8 125
Density, constant purge system for measuring.....8 37
Design factors, in machine efficiency.....8 536
for molding, glass reinforced parts.....8 177
Design suggestions for honeycomb sandwich.....8 375

Detectors for liquid level....8 534
Diametral clearance, in brazing, nomograph for....8 366
Diesel engine, turbocharger for....8 424
Diesel engine fuel economy....7 H9
Differential gage pressure....8 52
Dimensional changes, with temperature....8 294
Diode modulators....7 I10
Diodes, solid-state switching....8 474
Dip soldering, of aluminum....8 373
Direct control air circuit....8 530
Discrete liquid-level detectors....8 534
Dissimilar metals, brazing of....8 365
Drafting standards-projections....7 A11
Drain hole, in electroplating....8 124
Drape forming of plastic....7 D4
Draw forming of plastic....7 D4
Drift transistor....8 472
Drives, belt and wire rope....7 E10
sheave diameter for v-belt....7 E9
Drive-system chart....8 428
Dry-clutch, torque in....8 300
Ductile iron, properties of....8 65
Ductile iron change gear....8 67
Durometer hardness....8 112
Duty cycle, in arc welding....8 175
Dynistor, characteristics of....8 474

— E —

Economics, diesel engine fuel....7 H9
plastic sheet forming....7 D4
premix materials....7 C15
Eddy-current clutch....8 426
Ejectors for suction pressure....7 J2
Elastomers, compatibility of....8 535
Electrical damage, to bearings....8 476
Electrolytic chromium....8 68
Electromechanical modulators....7 I12
Electron beam machining....8 176
Electronic standards....8 470
Electroplating, designing for better....8 124
Electrostatic effect, on bearings....8 467
Elongation of filler metal....8 367
Engines, diesel fuel economy....7 H9
exhaust system noise control....7 H14
rocket....8 413
single cylinder, rumble in....7 H2
Enthalpy-temperature chart....8 104
Epoxy, resin....7 C5
Epoxy-fiber compositions....8 166
Erosion....8 63
Ethycellulose, forming of....7 D6
Evaluation of industrial reports....7 A2
Exhaust system noise control....7 H14
Exponential curve fitting....7 A16
Extruded rubber....8 164

— F —

Fan, centrifugal, manometer used in....8 37
Fasteners, threaded sealant for....7 G7
Fatigue, titanium....7 B3
Fatigue-resistant structures....8 298
Filler metal, in brazing, elongation of....8 367
Flame, soldering, for aluminum....8 372
Flange design and gasket selection....7 F2
Flat belt formulas....7 E11
Flat parts, electroplating of....8 109
Flexible mounting systems, isolation curve for....8 295
Flowmeter....8 36
Fluid circuits, trouble shooting....7 J15
Fluid control, sealants for....8 541
Fluid couplings, operating principles....7 E15
Fluid power circuits....8 538
Fluid power diagrams....8 542
Fluids, hydrostatic head of....8 533
synthetic hydraulic....8 535
Foot valve, two way....8 532
Forming, plastic sheet....7 D4
precision compression....7 D14
titanium extrusions....7 D2
Four-layer diodes, characteristics of....8 474
Four-way valve....8 530
Fretting....8 63
Fretting fatigue failure....7 F15
Friction, materials....7 C16
Fuel meters....8 36
Furnaces, solar....7 A14
Furnace soldering, of aluminum....8 373

— G —

Galling screw-threads....8 364
Galvanic corrosion....8 63
Gap change, in brazing....8 365
Gas-shielded electrode....8 173
Gaskets, selection and flange design....7 F2
Gears, chains, belts, comparison of....8 210
Gears, failures related to lubricants....7 E2
planetary....8 214
spur, nylon (Zytel) design of....8 204
Geometric curve sketching....7 A16
Germanium rectifiers....7 I3
Glass-fiber brush soldering....8 372, 374
Glass-protected steel....7 C10
Glass reinforced plastics, fastening of....8 368
Graphite pigment coatings....7 D9
Gray iron, machinability of....8 66
"weeping" in....8 67
Grinding wheel soldering, of aluminum....8 374
GR-S(Buna-S), properties of....8 112
Gyroscope precession torques....7 H7

— H —

Hafnium....8 68
Hardness, conversion of, Knoop to Vickers....8 38
durometer....8 112
Heat treatment, high purity aluminum....7 B6
ph steels....7 B10
ultra strength steels....7 B14
Heavy-duty compressors....7 J12
Helical springs, nomograms for....8 292
Hexagon locknuts, locking ability of....7 G6
High-temperature, effect on reinforced plastics....8 120
Hole tolerance, in electroplating....8 125
Honeycomb sandwich, designing with....8 373
Hot plate soldering, of aluminum....8 371
Hot upsetting....8 74
Human operators, control devices for....8 39
Hydraulic, actuators, resonant frequency....7 J5
Hydraulic circuits, design of....8 539
Hydraulic drive....8 429
Hydraulic fluids, synthetic....8 535
Hydrostatic head, nomograph for....8 533
Hypalon, properties of....8 113
Hyperbolic curve fitting....7 A16

— I —

Indexing clutches....7 E18
Induction welding....7 G4
Industrial reports, preparation and evaluation....7 A2
Intercooler, on turbocharger....8 426
Inter-face identification....8 37
Intergranular corrosion....8 63
Intrinsic-barrier transistors....7 I14
Involute splines, design advantages of, new standards for....8 208
IRE standards on reference designations....7 I4
Iron, ductile....8 65
malleable....8 70
Isolation efficiency curve....8 295

— J —

Joining, friction materials....7 C17
plastics....7 G2
tubing....7 G12
Joints, of dissimilar metals....8 366

— K —

Knoop-Vickers hardness conversion....8 38

— L —

Leaded steel, machinability of....8 66
Least-mesh angle, of planetary gears....8 216

Leather, belting, plastic-core 7 E14
effects of medium on 7 C9
Length, spring minimum 7 F4
Limit switches, electrical,
in air circuits 8 532
Liquid cooling, for electronic
equipment 8 466
Liquid level, constant purge
system for 8 37
detectors 8 534
intermittent purge system for ... 8 38
Liquids, head, nomogram for 8 533
Locking ability of hexagon
locknuts 7 G6
Lubricants, gear failures related to 7 E2

—M—

Machine efficiency, design
factors in 8 536
Machining, ultrasonic 7 D12
ultra-strength steel 7 B13
Magnesia ceramic 8 118
Magnesium alloy treatment 7 C4
Magnetic, modulators 7 I10
Malleable iron 8 70
Manometers, theory and
application of 8 36
Manual arc-welding 8 172
Match plate mold forming 7 D5
Materials, effects of medium on ... 7 C8
friction 7 C16
phenolic premix 7 C12
piston rings 7 F8
polyester premix 7 C12
spring 7 B12
Measurement of physical variables . 7 A14
Mechanical joining of plastic 7 G2
methods of joining tubing 7 G2
Metal, metals (see also metal in
question)
aluminum 7 B6
bronze, springs 7 B12
dissimilar, brazing of 8 365
effect of medium on 7 C8
filler, in brazing 8 367
for tomorrow 8 68
iron, ductile 8 65
malleable 8 70
machinability chart for 8 66
rectifiers 7 I2
stampings 8 170
steel, austenitic 8 74
fretting fatigue failure 7 F15
martensitic 8 74
nickel, dependability of 7 D11
springs 7 B12
precipitation hardening 7 B8
stainless (wire) 8 74
AISI type numbers for 8 75
titanium, elevated temperature . 7 B2
forming of 7 D2
fretting fatigure failure 7 F15
wrought iron 7 B5
Metallic, friction materials 7 C16
Metal spraying 8 74
Meters, flow 8 36
fuel 8 36
MIL-L-7808 ..... 8 536
Minimum spring values 7 F4
MLO-8200 ..... 8 536
Molybdenum 8 68
Molybdenum-bearing alloys 7 B16
Motors, alternating current,
polyphase 7 H6
single phase 7 H6
direct current 7 H6
guide to 7 H6
limited end float coupling 7 E6
Mounting tabs, in electroplating . 8 124

—N—

Neoprene, effect of medium on 7 C8
properties of 8 112
Nickel plating, designing for 8 124
Nitrile rubber, compatibility of 8 536
properties of 8 112
Noise control, engine exhaust
system 7 H14
Nomograms, bearing heat and
dissipation 7 F10
construction of 8 26
diametral clearance 8 366
gyroscope precision torque 7 H8
helical springs 8 292
liquid head 8 533
switch-time 7 I19
Nondestructive testing symbols ... 7 A12
Nylon resin (Zytel) spur gears 8 204

—O—

Operating principles in fluid
couplings 7 E15
Optical comparators 7 A5
OS-45 (silicate) 8 536
Overrunning clutches 7 E18

—P—

Paper, effects of medium on 7 C9
Pearlitic malleable castings 7 D7
Phenolic resin, premix 7 C12
properties 7 C11
effects of medium on 7 C9
in reinforced plastics 8 120
Photosensitive transistors 8 473
Pilot valve, times, in air circuits .. 8 531
Piston rings, plastic 7 F7
Planetary gear-trains 8 214
Plastic properties chart 7 C11
Plastic-core leather belting 7 E14
Plastics, effects of medium on 7 C8
epoxy-fiber 8 166
epoxy-resin 7 C5
forming of sheet 7 C4
glass reinforced 8 368
mechanical joining of 7 G2
reinforced 8 120
properties and applications 7 C28
Plates, circular, symmetrical
bending of 8 296
Plating, designing for better 8 124
pnpn and pnpm switching diodes .. 8 474
Polyamide 7 C11
Polycarbonate 7 C11
Polyester, premix 7 C12
Polyester-glass, pressure cast 8 168
Polyethylene, forming of 7 D6
Polystyrene 7 C11
Polyurethane, properties of 8 113
Polyvinylchloride 7 C11
designing with 8 115
rigid, creep curves for 8 117
Porcelain, enamel coatings 7 C2
Power transistors 8 473
Power transmission, belt and
rope drives 7 E10
clutches 7 E18
gears 7 E2
plastic-core leather belts 7 E14
torque converters 7 E15
Precision compression forming 7 D14
Preparation of industrial reports ... 7 A2
Press fitting plastics 7 G3
Principles, fluid coupling operation . 7 E15
Projections, drafting 7 A11
Properties of, alloys to combat
corrosion 7 B17
aluminum, permanent mold
castings 7 B7
sand castings 7 B7
belt and rope drive materials 7 E10
friction materials 7 C5
glass 7 C17
industrial crystals 7 C10
plastics 7 C11
mechanical joining 7 G5
phenolix premix 7 C14
piston rings 7 F8
polyester premix 7 C14
porcelain enamel 7 C3
sealant for fasteners 7 G8
steel, precipitation hardening ... 7 B8
ultra-strength 7 B14
titanium 7 B2
Pumps, hydraulic 7 J17
PVT formula, gear failures 7 E3

—R—

Radioactive testing, gears 7 E5
Ravigneaux gear train 8 215
Reaction-flux soldering 8 372, 374
Recessed parts, in electroplating ... 8 127
Reciprocating system, air operated . 8 532
Rectifier, metal 7 I2
Rectiflow drive 8 429
Reinforced plastics 8 122
Relays, sensitive dc 7 I8
Remote-control air circuit 8 530
Reports, industrial 7 A2
Resin, epoxy 7 C5
phenolic 7 C14
polyester 7 C14
Resistive and conductive coatings .. 7 D8
Resonant frequency, hydraulic
actuators 7 J5
Rigid polyvinylchloride 8 115
forming of 7 D6
Rivet and bolt joints for joining
tubing 7 G12

Riveting, blind....7 G2
Rocket-engine systems....8 418
Rubber, acrylic....8 113
effects of medium on....7 C8
extruded....8 164
nitrile....8 536
properties of....8 112
Rubberlike hydraulic seals....8 535
Rumble in single cylinder engines..7 H2

—S—

Scoring, gear failure....7 E2
Screw-threads, problems in....8 364
Sealant for threaded fasteners....7 G7
Sealants, for fluid control....8 541
Seals, for hydraulic fluids....8 535
Selenium rectifiers....7 I3
Self-locking dc relays....7 I9
Semi-conductors....7 I2
Sensitive dc relays....7 I8
Sequence air-circuit, semi-automatic....8 531
Sequence cylinder-action....8 532
Servo modulators....7 I10
Servomotor, modifications to....8 421
Sheave diameters for v-drives....7 E9
Silicon rectifiers....7 I3
Silicon-bearing alloys....7 B16
Silicone, effects of medium on....7 C8
Silicone rubber, properties of....8 113
Silicones, compatibility of, in plating....8 125
Silver-pigment coatings....7 D9
Single-acting cylinder....8 530
Single-cycle feed and return, in air circuits....8 532
Single-cylinder engines, rumble in..7 H2
Skydrol....8 536
Slide forming....8 74
Slip forming of plastic....7 D5
Snap-back forming of plastic....7 D5
Solar furnaces....7 A14
Soldering, of aluminum....8 120
Solders, for aluminum....8 122
Solid-state switches (diodes)....8 474
Specific gravity, indication of....8 37
Spin welding of plastic....7 G4
Splines, involute, design advantages of new standards for....8 208
Sprag-type clutches....7 E18
Springs, design of minimum....7 F4
helical, stress and stiffness in....8 292
material....7 B12
Spur gears, nylon resin (Zytel), capacity of....8 206
design of....8 204
Stainless steel wire, ten uses of....8 74
Stampings, metal....8 170
Standards, drafting, projections....7 A11
electronic....8 470
interference-fit threads....7 G16
IRE on reference designations....7 I4
NEMA, coupling end float....7 E8
nondestructive testing symbols..7 A12
punch press operation....7 H12
steel bolt markings....7 G17
Steady-state axial flow forces on pneumatic valves....7 J9
Steel bolts, markings of....7 G17
Steel, austenitic....8 74
glass-protected....7 C10
machinability of....8 66
martensitic....8 74
nickel, dependability of....7 D11
precipitation hardening....7 B8
spring materials....7 B12
ultra-strength....7 B13
wire, stainless....8 74
Straight line curve fitting....7 A15
Stress analysis, brittle coating in..8 302
Stress corrosion....8 63
Stress rupture, titanium....7 B2
Styrene, forming of....7 D6
Submerged-arc welding....8 173
Supercharger pressure ratio....8 426
Surface barrier transistors....8 473
Switches, solid-state....8 474
Switch-time nomograph....7 I19
Symbols, nondestructive test....7 A12
Synthetic hydraulic fluids, seals for 8 535

—T—

Tank gages....8 37
Tantalum....8 69
Teflon, effects of medium on....7 C9
Telescopic joints for joining tubing....7 G13
Temperature flash formula, gear failures....7 E3
Temperature, effect on, rectifiers..7 I2
nickel steel....7 D11
titanium....7 B2
Temperature change, dimensional effect of....8 294
Tetrode transistor....8 472
Thermistors, types and uses....7 I16
Thermoplastics....7 D6
Thin doublers for structures....8 298
Thiokol, effects of medium on....7 C8
properties of....8 113
Thread-fit problems....8 364
Thread joints for joining tubing...7 G12
Threads, interference-fit standards..7 G16
sealant for....7 G7
Three-way valves....8 530
Thrust chambers, rocket....8 419
Time dwell in air circuit....8 531
Titanium....8 68
at elevated temperature....7 B2
forming extrusions of....7 D2
Torque, bolts....7 F2
characteristics, sealant....7 G7
in dry clutches....8 300
loss, belt drives....7 E13
valve linkages....7 J7
Trade names, of solid-state switches....8 538
plastics....7 C11
servo modulators....7 I10
ultra-strength steels....7 B14
Transistors, design and construction of....8 472
intrinsic-barrier....7 I14
Treatment, magnesium alloy....7 C4
Tubing, mechanical joining....7 G12
Tungsten....8 69
Tungsten electrode, for arc welding....8 173
Turbochargers, how to select....8 424
Two-way valve....8 532

—U—

Ultra-strength steels....7 B13
Ultrasonic, machining....7 D12
Ultrasonic soldering, of aluminum..8 374

—V—

V-belt formulas....7 E11
Vacuum forming of plastic....7 D4
Valve characteristics....7 J6
Valve, cam controlled....8 532
foot, two-way....8 532
four-way....8 530
identification....8 34
pilot....8 531
three-way....8 530
Valves, pneumatic, steady-state axial flow forces....7 J9
Vanadium....8 68
Vickers-Knoop hardness conversion....8 38
Volume, spring minimum....7 F4

—W—

Warm heading....8 74
Wear, gears....7 E4
"Weeping" in gray iron....8 67
Weight, spring minimum....7 F4
Welding, induction, of plastic....7 G4
ph steels....7 B10
spin of plastic....7 G4
ultra-strength steel....7 B13
Welding rods....8 74
Wire, stainless steel, ten uses of...8 74
Wire cloth....8 74
Wire rope and belt drives....7 E10
Wrapping, titanium extrusions....7 D2

—Z—

Zirconium....8 68
Zytel spur gears, design of....8 204

INDEX OF PRODUCTS ADVERTISED in This Issue

This index is designed for easy reference to any advertised product in which you are particularly interested. Most advertising for a specific product will be found in its appropriate section. However, a few are not because some advertisements describe several different products. More detailed information on the products classified below can be obtained by using the Reader Service Cards on pages 17 thru 22. Note: The key numbers located on the advertisements should be circled on these cards—*not* the page numbers below.

Actuators, hydraulic ...517, 537, 541, 545
mechanical ...237, 268
pneumatic ...537, 541, 545
Adapters, angle ... 524
Adhesives ...158, 365
Air Motors
(see Motors, Air)
Alternators
(see Generators)
Aluminum Alloys ...76-77, 78, 79, 83 84, 98, 187, 191
Aluminum Coated Sheet & Strip...80-81
Amplifiers ... 485
Assemblies, electrical ... 485
hydraulic ...517, 524, 545
mechanical ...308, 328
pneumatic ... 545
sheet metal ...307, 371, 488
structural ... 320
Axles ...244, 384

Balls ...129, 228, 315
Ball screws or splines ...237, 267
Bars, metal ...90, 94, 96, 98, 296
plastic ... 148
Bearing materials ...90, 100, 129, 182 228, 233, 296, 310, 315, 322, 334
Bearings, ball ...182, 225, 228, 248-249 264-265, 293, 310, 315, 324, 329
jewel ...325, 334
miniature ...228, 310, 315, 322
needle ...300-301, 313
oilless ...128, 129, 225, 233 264-265, 322, 327
roller..182, 248-249, 264-265, 293, 294-295, 300-301, 313, 315, 327, 329
self-aligning...228, 248-249, 293, 308 313, 324, 329
self-lubricating ...100, 128, 129, 225 233, 248-249, 308, 322, 324, 327
sleeve ...100, 128, 180, 233, 248-249 264-265, 316, 322, 324, 327, 330
Bellows ...128, 146-147, 154, 158 299, 324, 328, 527
Belts ... 298
Belts, Timing ...248-249, 263
Belts, V ...243, 264-265
Beryllium ...84, 191
Bi-Metal ...87, 90, 487
Blowers ...317, 321, 404-405 424-425, 536, 538
Bolts ...80-81, 370, 373, 375 378, 379, 382

Boosters ... 526
Brakes, electric ...250-251, 416-417
hydraulic ... 302
mechanical ...219, 248-249, 250-251
pneumatic ...250-251, 302
solenoid ... 469
Brass ...84, 90, 95, 96, 180, 487
Brazing, alloys..90, 95, 96, 356, 384, 487
supplies ...356, 384
Breadboard Kits ...51, 322
Bronze ...84, 90, 96, 180
Brush Holders ...460, 476
Brushes, Electrical ...460, 487

Bushings ...100, 128, 129, 146-147, 182 293, 313, 322, 324, 328, 329 330, 374, 381
Bushings, Strain Relief...322, 327, 329 474, 490

Cabinets ...51, 56, 197, 307
Cable ...328, 474
Cable, Push-Pull ... 306
Cam Fasteners ... 358
Cam Followers ...128, 313, 330
Cams ...128, 150, 182, 196, 236, 330
Caps ... 553
Carbide Alloys ...94, 99
Casters ...319, 330
Castings ...94, 96, 182, 185, 186 193, 194-195, 232
Castings, Centrifugal ...94, 101, 180
Ceramics ...84, 131, 160
Chains, conveyor ...225, 248-149, 255, 258, 264-265
roller ...225, 226, 248-249 255, 258, 262, 264-265
silent ...226, 248-249, 262
Chemical Treatments ...126-127, 159
Chemicals ...126-127
Choppers ... 466
Clad Metals ...83, 87, 90, 94, 130 182, 487
Clamps ...296, 322, 370, 472, 489, 527
Clamps, Fixture ... 489
Clamps, Hose ...296, 358, 369, 489 524, 527
Clips ... 296
Clips, Electrical ...51, 296, 472, 489
Closures ...358, 451, 459
Clutches, electrical ...238, 250-251
hydraulic ...238, 254, 263
mechanical ...219, 220, 224, 227, 228 229, 238, 248-249, 253, 254, 256 263, 322
pneumatic ...238, 250-251, 264-265
Coatings ...126-127, 128, 131, 135 145, 154, 156, 158, 159
Coils ...464, 489
Cold Headed Parts ...373, 376, 382 384, 487

Collector Rings ...83, 428, 460, 476, 487
Commutators ... 428
Compressors ...246-247, 536, 538
Conduit ...80-81
Connectors, electrical ...51, 371, 459, 461 463, 471, 474, 552
hose ...318, 518, 524
tube ...51, 318, 518, 524
Contactors ...292, 448-449, 487
Contacts & Contact Materials....292, 371 476, 487

Controllers ...448-449, 464, 466, 484
Control Motors ... 458
Controls, clutch ...250, 251
electrical ...312, 406-407, 420, 426 448-449, 456-457, 463, 464, 466 472, 474, 475, 479, 480, 481 483, 484
electronic ...312, 456-457, 481, 483 484, 490
hydraulic ...299, 517, 528-529, 533 537, 541, 545, 547, 554
mechanical ...224, 312
pneumatic ...299, 514, 533, 537 541, 545, 554
push-pull ... 306
Conveyor Belts ...248-249, 298
Copper & Copper Alloys....79, 83, 84, 90 96, 180, 193, 487
Cords ...158, 474
Cores ... 297
Cork Compositions ...324, 328
Counters ...312, 465, 483
Couplings
(see Connectors, Electrical)
Couplings, electrical ...371, 552
hose ...318, 518, 524, 527
hydraulic & pneumatic....227, 238, 244 248-249, 254, 518, 524, 527, 552
mechanical ...218, 220, 222-223, 224 225, 227, 232, 240, 244, 248-249 253, 254, 255, 258, 263, 264-265 322, 552
rotating ...232, 263, 527
tube ...518, 527
Cylinders, hydraulic....101, 331, 511, 513 516, 517, 525, 530, 533, 537 543, 548, 551
pneumatic ...511, 513, 514, 516, 525 530, 533, 537, 543, 548, 551

Deep Drawing ...183, 488
Dials ...156, 320, 454, 488
Diaphragms ...128, 154, 155, 324 328, 545

Die Castings ...96, 189
Differentials ...227, 245, 262, 322
Drafting, instruments ...52, 53
machines ...52, 53
supplies ...45, 47, 48, 52, 53, 54, 56
Drives, adjustable speed ...248-249, 256 259, 266, 421
gear ...225, 245, 248-249, 254, 259 260-261, 264-265, 322
hydraulic or fluid...238, 248-249, 254 264-265, 266
mechanical ...225, 232, 238, 245 246-247, 248-249, 256, 259 260-261, 264-265, 266, 421
right-angle ...225, 226, 232, 246-247 248-249, 254, 259, 260-261, 264-265
shaft-mounted ...225, 232, 246-247 248-249, 256, 259, 260-261 263, 264-265
timing ...220, 248-249, 458
variable speed ...225, 248-249, 254 256, 266, 421

Electrical & Electronic Components, Custom Made ...154, 155, 160, 182 190, 197, 324, 325, 328, 369 371, 422, 428, 448-449, 461 463, 472, 474, 475, 480, 481 485, 486, 487, 488, 489, 490
(see also Production Services)
Electrochemical Finishes & Treatments 158, 159
Electroplating Equipment ... 159
Engine Indicators & Controls... 426
Engineering Services ..154, 155, 325, 327 474, 4[illegible], 533, 543
(see also Production Services)

Engines 408, 413, 414, 419, 426
Engravers 488
Expanded Materials 95, 132-133
Extrusions, metallic 94, 95, 98,193
nonmetallic 128, 158, 193, 371

Fabricated Plastics
(see Plastics, Fabricated)
Fabricated Steel
(see Sheet Fabricated, Structural Forms & Shapes, Weldments)
Fabrics 122, 144, 154, 158
Fabrics, Coated ..122, 154, 158, 324, 328
Fans 317
Fastening Methods..51, 296, 328, 354-355 357, 358, 359, 360, 362, 363, 364 365, 366, 369, 370, 371, 372, 373 374, 375, 377, 378, 379, 381 382, 383, 384
Felt 122, 134, 144, 324, 328
Fibre 138, 150, 158, 324, 328
Files 52, 56
Filters, air 190, 326, 532, 549
hydraulic 326, 532
Finishing Equipment & Supplies..... 156 158, 159
Finishing, Decorative 149, 151, 156 158, 159
Finishing, Protective 128, 131, 149 151, 154, 156, 158, 159
Fittings, Hose, Pipe & Tube.....154, 381 512, 518, 524, 527, 534, 536 542, 550
Flanges 155, 375, 527
Flexible Couplings 155, 218, 220, 225 227, 232, 239, 248-249, 252 255, 264-265, 322
Flexible Shafts 252, 258, 314
Floats 333
Flow Regulators 554
Forgings 94, 96, 193
Friction Materials 324, 328
Furniture, Engineering Dept.....48, 52 53, 54
Fuse Holders 51

Gage Protectors 526
Gages, Pressure or Vacuum.....326, 485
Gaskets 122, 128, 146-147, 154, 155 190, 303, 324, 328, 536
Gear Boxes ...227, 234-235, 245, 248-249 254, 257, 266, 322
Gear Motors ..225, 232, 234-235, 248-249 259, 260-261, 404-405, 410-411 416-417, 418, 421, 424-425 426, 427, 428
(see also Motor Reducers)
Gears 154, 196, 218, 221, 225, 226 227, 231, 232, 238, 239, 240, 241 242, 245, 246-247, 248-249, 258 260-261, 262, 322, 330
Generators, A-C 404-405
D-C 404-405, 421
Glass 125
Glass, Fabricated 78, 125
Glass Parts 125
Gold Alloys 83, 86, 356, 487
Grommets 146-147, 324, 328, 330 358, 371, 487

Handles & Knobs.....129, 156, 319, 320 322, 330, 466
Heating Units 452, 467, 472, 480
Hermetic Sealing 155, 455, 464
High Temperature Alloys...79, 80-81, 90 94, 101, 155
Hinges 370, 372
Hose & Tubing 102, 128, 318, 512 518, 524, 527, 540

Inspection Equipment 477
Instruments, electrical 485, 486
hydraulic 485, 526
pneumatic 485, 526
Insulation ...128, 131, 132-133, 142, 143 154, 155, 158, 182, 324, 328
Insulators ..150, 155, 160, 182, 325, 330

Jacks, Positioning 51, 254, 257
Jewels 325, 334
Joints, expansion 299
instrument 240
swing & swivel 527, 552
universal 225, 227, 230, 238, 240
Junction Boxes 463

Lamps 323, 371, 454, 463, 473
Lamps, Indicator 51, 371, 463, 473
Laminated Metals 83, 487
Laminated Plastics
(see Plastics, Laminated)
Latches 330, 358, 370, 488
Lead 324, 328
Leather 324, 328, 536
Liquid Level Controls.....466, 484
Locks 322, 370
Louvers 307, 488
Lubricants 311, 488
Lubricating Equipment 311
Lubricators, Air-line 311, 549

Machined Parts 96, 101, 128, 129 182, 333, 487
Magnesium Alloys 191
Magnetic Materials 79, 83, 94, 160
Magnetic Shielding 478
Magnets 79, 160, 462
Magnet Wire 79
Manifolds, Hydraulic, Brazed..... 549
Markers, Wire & Insulation..... 486
Metal Bonded to Plastic....128, 143, 155 192, 488
Metal Bonded to Wood..... 488
Metal Forming 183, 487, 488
Metal Powder 80-81
Metal, Pre-Finished 87
Meters, Electrical 458
Mica, Glass-bonded 150
Moldings, glass
(see glass parts)
plastics
(see plastic parts)
powdered metal
(see powdered metal parts)
rubber
(see rubber parts)
Molybdenum Alloys 95
Motor Reducers 225, 232, 234-235 248-249, 254, 260-261, 404-405 410-411, 416-417, 418, 424-425 426, 427, 428
(see also Gear Motors)
Motor Starters 420, 448-449, 463
Motors, A-C, fractional.....410-411, 415 416-417, 418, 421, 423, 424-425 426, 427, 428, 448-449
integral 409, 410-411, 416-417, 421 427, 448-449
sub-fractional ...404-405, 415, 418, 422 423, 428, 458
Motors, Air 536, 538
Motors, D-C, fractional.....415, 418, 421 424-425
integral 421
sub-fractional 404-405, 415, 418 422, 458
Motors, High Frequency, fractional... 415 427
sub-fractional 415, 458
Motors, hydraulic or fluid...248-249, 517 528-529, 535, 547
mechanical 428
Mountings ...122, 146-147, 248-249, 324

Name Plates 190, 454, 486
Nickel Alloys 79, 82, 83, 90, 101 180, 487
Nickel Silver 84, 90, 96, 487
Nozzles, Spray 542
Nuts 80-81, 330, 357, 366, 367, 369 371, 373, 375, 376, 377, 380 381, 383

Overload Relays 448-449

Packings 128, 154, 158, 324, 328 510, 520-521, 536, 543, 546, 548
Paints 128, 151
Palladium Alloys 86, 487
Panels 78, 192, 197, 307, 454
Paper 158
Paper Insulation 158, 324, 328
Pencils 52
Perforated Materials 89, 188
Phosphor Bronze 84, 90, 487
Photoelectric Cells 481
Pillow Blocks 225, 248-249, 322, 324
Pilot Lights 463, 483
Pinions 196, 218, 227, 232 245, 248-249
Pins 296, 360, 363, 367, 378
Pipe 80-81, 94, 101, 180
Plastic Film..45, 128, 142, 145, 149, 160
Plastic Parts 78, 122, 128, 129 139, 141, 143, 146-147, 150, 154 155, 156, 157, 158, 160, 182, 192 320, 324, 328, 371, 474, 520-521
Plastics .....78, 123-124, 128, 129 132-133, 135, 136-137, 139, 141 143, 145, 148, 149, 152-153, 154 1[illegible], 158, 160, 182, 192, 543
Plastics, Bonded 78, 129, 130, 135 143, 155, 182, 192
Plastics, Fabricated 78, 128, 129, 139 143, 148, 154, 155, 156, 158, 160 182, 192, 193, 320, 324, 328
Plastics, Foam 135, 145, 152-153, 192
Plastics, Laminated 122, 128, 129 130, 135, 143, 149, 150, 158 160, 182, 324, 328
Plate Fabricated 307
Plates 94, 98, 297, 327
Platinum Alloys 86, 356, 487
Plugs 371, 463, 474
Powdered Metal Parts.....181, 188, 193 196, 233, 376
Power Packs
electrical & electronic.....456-457, 482
hydraulic 516, 517, 524, 530
Power Take-Offs..227, 229, 238, 245, 254
Power Units 227, 231, 408
Precious Metal Alloys.....83, 487
Presses 304, 530
Printed Circuits 182, 371, 488
Production Machines & Processes.... 190 236, 362
Production Services 154, 155, 182 325, 488, 533
(see also Engineering Services)
Programmers 461

INDEX OF PRODUCTS ADVERTISED in This Issue *(continued)*

Protective Devices, Motor..12[illegible], 224, 463
Pulleys 129, 154, 225, 228 248-249, 256
Pumps
air 526, 536, 538
hydraulic 245, 246-247, 331, 515 517, 519, 526, 528-529, 531 535, 543, 547, 553
liquid 192, 218, 246-247, 331, 519 522, 531, 543, 553
rotary 218, 246-247, 515, 519, 531 536, 538, 543, 553
vacuum 536, 538
Punchings, Plastics 129, 324, 328

Racks 51
Ratchets 239
Rectifiers 159
Regulators
electrical 463, 482
pneumatic 549
Relays 404-405, 406-407, 448-449 450, 456-457, 464, 466 474, 481, 482
Reproduction Equipment 45, 53, 55
Reproduction Supplies 45, 47, 55
Resins 135, 136-137, 145, 152-153
Resistors 79, 472
Retaining Rings..150, 296, 358, 361, 366
Revolving Joints
(see Joints, Swing & Swivel)
Rings 91, 128, 303, 309, 324, 328 330, 460, 476, 520-521, 543, 548
Rivets 80-81, 303, 354-355, 360, 362 370, 371, 379, 384, 487
Rod Ends 329
Rods
metallic 94, 96, 98
nonmetallic 148, 150, 324, 325 328, 330
Rollers 129, 293, 330
Rolls 101, 190
Rubber 134, 135, 155, 192, 324 327, 328, 543
Rubber-Bonded-to-Metal 135, 146-147 154, 155, 190, 192, 324, 327 328, 378, 510
Rubber Coated Parts.....154, 158, 190 192, 327
Rubber Lining 158, 192, 327
Rubber Parts 134, 146-147, 154, 155 158, 190, 192, 324, 327, 328, 378 510, 545, 546, 550

Screw Fasteners 354-355, 357, 364 367, 373, 376, 382, 384
Screw Machine Parts....96, 182, 193, 487
Screws 51, 330, 364, 367, 373, 374 376, 378, 380, 382, 384
Screw Thread Inserts...354-355, 357, 362 364, 373, 374, 382, 552
Sealants 365
Seals 128, 146-147, 154, 155 250-251, 303, 322, 323, 324, 328 331, 455, 459, 510, 520-521 536, 543, 545, 546, 548, 550
Seating, Work Equipment..... 320
Servomechanism Components 485, 545
Shapes, Roll Formed.....94, 487
Shafts 227, 245, 330
Sheaves 256, 264-265
Sheet & Strip, Tubed..... 487
Sheet Fabricated 78, 80-81, 191 197, 307, 302
Sheets
metal 80-81, 94, 130, 197
plastic 128, 148, 158, 160, 182 324, 328
rubber 154, 158, 324, 328
Shims 324, 328, 365
Silicone Rubber 150, 155, 324, 328
Silver Alloys 83, 356, 384, 487
Sleeves, Pliable 550
Slides 304, 308
Slides, Roller 267
Slip Rings
(see Collector Rings)
Sockets, Tubes 51
Solenoids 464, 469, 471, 474
Sound-Level Meter 54
Sound Analyzer 54
Spacers 324, 328, 357
Special Shapes & Sections.....98, 155 307, 487
Specialty Fasteners 51, 357, 358 362, 370, 371, 376, 378, 381 382, 383, 384
(Pipe Hangers, Special Cold Headed Parts, etc.)
Specialty Metals 79, 86, 87, 90, 101
Speed Detectors 479
Speed Increasers & Reducers.....225, 227 232, 234-235, 240, 246-247, 248-249 256, 260-261, 264-265
Spindles 308, 320
Spinning 183, 197
Splines 218, 245, 262
Spraying 158
Springs 292, 296, 322, 324, 487
Sprockets 225, 248-249, 255, 258 263, 264-265, 330
Stampings ..196, 296, 324, 328, 369, 487
Steel
alloy 80-81, 82, 85, 94, 97 101, 180, 296, 369
carbon 80-81, 82, 85, 89, 97 101, 180, 296, 369
coated 80-81, 97, 130, 369
electrical 80-81, 94, 487
spring 80-81, 89, 97, 296, 369
stainless 80-81, 82, 84, 94, 97 101, 180, 296, 487
tool 80-81, 82, 94
Strainers 333
Strain Gages 477, 485, 486
Strip, Metallic 79, 80-81, 86, 90 94, 297, 487
Strip, Nonmetallic 128, 324, 328
Structural Forms & Shapes....78, 98, 191
Studs 80-81, 357, 358, 359, 381
Subcontracting Services 197, 307
Swaged Parts 328, 487
Switches 371, 448-449, 456-457 463, 464, 470, 472, 474 476, 478, 480, 486

Tables, Dial-Feed 236
Tags 488
Tapes 154, 155
Tapes, Insulating
(see Insulation)
Templates 54
Terminals & Terminal Boards....51, 455 459, 461, 481, 490
Testing Machines & Equipment...240, 526
Thermistors 482
Thermocouples 79, 83, 86, 484
Thermometers 326, 484
Thermostats 453, 467, 478, 479, 484
Thread Rolling 381
Timers 458, 479, 481, 483
Timing Motors 422, 458
Titanium 80-81, 95, 191
Tools 322, 324, 475
Torque Converters
(see Couplings)
Tracing Cloth 46
Tracing Paper 47
Transducers 468, 477, 485, 486
Transmissions 219, 227, 238, 244 248-249, 254
Traps, Air 333
Tube Fabricating 95, 155, 193, 527
Tube Mills 95
Tubes 80-81, 92-93, 95, 101, 102 155, 193, 299, 487, 527
Tubing
flexible metal 102, 318
plastic 128, 143, 146-147 155, 160, 193
rubber 146-147, 155, 324, 328
seamless 86, 92-93, 94, 95, 193 487, 524, 527
welded 80-81, 94, 524, 527

Valve Controls, Motorized..523, 534, 554
Valves
air 250-251, 333, 514, 516, 530 533, 534, 537, 539, 548 550, 551, 552, 554
control 333, 514, 516, 523, 525 539, 550, 552, 554
hydraulic 192, 245, 305, 331, 516 517, 525, 530, 535, 539, 542 547, 550, 551, 552, 554
liquid flow 136-137, 192, 305 333, 523, 534, 539 547, 550, 552, 554
motorized 554
solenoid 514, 516, 523, 530 539, 551, 554
Varnish 128
Vibration Dampers
mechanical 122, 318, 326, 371
Vibration Mountings 122, 326, 371

Washers 122, 293, 296, 324 328, 330, 369, 381
Wear Materials 94, 128, 131, 325
Wear Plates 128
Welding
equipment 359
nuts & screws.....357, 359, 366 375, 376, 378
supplies 96
Weldments 101, 307
Wheels 319, 322, 330
Wheels, Blower Impellers..... 317
Wire 79, 80-81, 86, 89, 90, 94 96, 474, 482, 487
Wire & Cable, Electric..... 474
Wire Cloth 89, 298, 326
Wire Forming.....196, 296, 487
Wire Rope 328
Wiring Devices 461, 463, 474, 490
Wiring Harnesses 51, 471
Wood Products 129, 140
Worms 218, 257, 262

X-Ray Equipment 190, 454

Zinc Coated Sheets.....80-81
Zinc Coated Strips.....80-81

TRADENAMES USED IN ADVERTISEMENTS in This Issue

The following list of tradenames of manufacturers and products in or related to the field of product design has been prepared from advertisements in this issue. This is not intended as a complete directory of tradenames, but is published as a service to the reader, for use in locating the manufacturer's name when only a purported tradename *mentioned in advertising in this issue*, is known. The editors for obvious reasons have not attempted to determine a manufacturer's right to the exclusive use of any such name. The intention is to list only tradenames shown in the advertisements that differ from the firm name. It was deemed unnecessary to include a tradename that is part of a firm name or forms the initials of it, inasmuch as the manufacturer's identity is immediately apparent. Addresses can be obtained from the advertisements which are indexed beginning on page 16.

AEROPAK Aero Research Instrument Co., Inc.
AGASTAT Elastic Stop Nut Corp. of America
AIRFLEX The Falk Corporation
AIR-GRIP Dodge Mfg. Corp.
AIRPURE Flanders Filters, Inc.
ALATHON E. I. du Pont de Nemours & Co. (Inc.)
ALGCO The Auburn Mfg. Co.
ALIRON Metals & Controls Div., Texas Instruments Inc.
ALLENPOINT The Allen Mfg. Co.
ALLENUT The Allen Mfg. Co.
ALL-MOTOR The Falk Corporation
ALODINE Amchem Products, Inc.
ALUMEL Hoskins Mfg. Co.
AMPLI-NYL AMP, Incorporated
ANACONDA American Brass Co., Anaconda Metal Hose Div.
ANGLGEAR Airborne Accessories Corp.
ARNOX Arnold Engineering Co.
BAKELITE Union Carbide Plastics Co.
BALL-LOK Avdel, Inc.
BRAZE Handy & Harman
BUND-L-TITE Dakota Engineering, Inc.
CAB-L-TITE Dakota Engineering, Inc.
CARMET Allegheny Ludlum Steel Corp.
CERTI-SEAL AMP Incorporated
CHEVRON Garlock, Inc.
CHOBERT Avdel, Inc.
CHROMALOX Edwin L. Wiegand Co.
CHROMEL Hoskins Mfg. Co.
CIRCLE ESS F. W. Stewart Corp.
CLAD-REX Simonlz Co., Clad-Rex Div.
CLAMP-LOCK Simmons Fastener Corp.
COLD-PREST Mueller Brass Co.
CO-NETIC Magnetic Shield Div., Perfection Mica Co.
COPEL Hoskins Mfg. Co.
COPYFLEX Chas. Bruning Co., Inc.
COUNT-PAK Veedor-Root, Inc.
CU-CON Electrolab Printed Circuits Corp.
CUNIFE Arnold Engineering Co.
CUSTOMEERED Eagle Picher Co., Ohio Rubber Co. Div.
CYCLOHM Howard Industries, Inc.
DACRON E. I. du Pont de Nemours & Co. (Inc.)
DANCO The Danielson Mfg. Co.
DAYFLEX Dayco Corp., Dayton Dayflex Plastics Co. Div.
DAZIC Winterburn Mfg. Co.
DECITRON Post Electronic Products, Div. Reid Bros. Co. Inc.
DELRIN E. I. du Pont de Nemours & Co. (Inc.)
DELROYD De Laval Steam Turbine Co.
DESK-O-MATIC Mayline Co., Inc.
DIALCO Dialight Corp.
DIAMOND Continental Diamond Fibre Corp.
DIAMOND H Hart Mfg. Co.
DILECTO Continental-Diamond Fibre Corp.
DOT United-Carr Fastener Corp., Carr Fastener Div. and The Ucinite Div.
DRYSEAL L and L Mfg. Co.
DUAL-LOCK Simmons Fastener Corp.
DUFELT The Felters Co.
DURAN CLAD Masland Duraleather Co.
DURA SEAL Durametallic Corp.
DURATRACE Ozalid Div., General Aniline & Film Corp.
DUREZ Hooker Chem. Corp., Durez Plastics Div.
DYFLON Southwest Products Co.
DYLAN Koppers Co., Inc., Plastics Div.
DYLENE Koppers Co., Inc., Plastics Div.
DYLITE Koppers Co., Inc., Plastics Div.
DYNACO Dynamic Gear Co., Inc.
DYNA-V Dodge Mfg. Corp.
EASY-FLO Handy & Harman
ECON-O-MISER Worcester Valve Co., Inc.
ELECTR-O-SEAL Parker Seal Co., Div. Parker Hannifin Corp.
ELECTRUNITE Republic Steel Corp.
EMCOR Ingersoll Products Div., Borg-Warner Corp.
ENAMELACE Maas & Walstein Co.
EQUIFLEX The Ucinite Co., Div. United-Carr Fastener Corp.
FADE-OUT Clearprint Paper Co.
FATIGUE-PROOF La Salle Steel Co.
FIREROD Watlow Electric Mfg. Co.
FLEXIDYNE Dodge Mfg. Corp.
FLEXLINE Fawick Airflex Div. Fawick Corporation
FLO-BALL Hydromatics, Inc.
FORMICA American Cyanamid, Formica Corp. (Subsidiary)
GARRETTIZING George K. Garrett Co., Inc.
GASK-O-SEAL Parker Seal Co., Div. Parker Hannifin Corp.
GEARMOTOR Link-Belt Co.
GORBOND Goshen Rubber Co., Inc.
GORTITE A & A Mfg. Co., Inc.
GRAPHALLOY Graphite Metallizing Corp.
GRIPCO Grip Nut Co.
GRIPMASTER George Walker Co.
GUIDEROL McGill Mfg. Co., Inc., Bearing Div.
GUSHER The Ruthman Machinery Co.
HAVEG Taunton Div., Haveg Industries, Inc.
HEALTHWAY Milsco Mfg. Co.
HI-FAX Hercules Powder Co., Inc.
HINGE-LOCK Simmons Fastener Corp.
HOOK-LOCK Simmons Fastener Corp.
HUGLOCK National Machine Products Co.
HYDRA-DRIVES Rockwell-Standard Corp., Transmission & Axle Div.
HYDRO-SHEAVE Twin Disc Clutch Co.
HY-ROLL Hyatt Bearings Div., General Motors Corp.
HYTRON The Imperial Brass Mfg. Co.
HY-VO Morse Chain Co.
IMPLEX Rohm & Haas Co.
IN-LINE Industrial Electronic Engineers, Inc.
IN-LINE Link-Belt Co.
INTERMITTOR Ferguson Machine Corp.
IRIDITE Allied Research Products, Inc.
IRILAC Allied Research Products, Inc.
ISOBRITE Allied Research Products, Inc.
ISOLITE United States Radium Corp.
ISOLOY Riverside-Alloy Metal Div., H. K. Porter Company, Inc.
JEEP Willys Motors, Inc., Industrial Engine Dept.
KENTANIUM Kennemetal, Inc.
KORD United States Rubber Co., Mechanical Goods Div.
KOVAR Metals & Controls Div., Texas Instruments, Inc.
KRALASTIC United States Rubber Co., Naugatuck Chem. Div.
K-SEAL Harrison Mfg. Co.
KWIK-THERM Cannon Electric Co.
LA-LED La Salle Steel Co.
LAUSON Tecumseh Products Co.
LEADERPOINT The Allen Mfg. Co.
LIGHT-MITE Stocker & Yale
LINEARSYN Sanborn Co., Industrial Div.
LINK-LOCK Simmons Fastener Corp.
LION South Chester Corp., Southco Div.
LIQUI-COOL Fawick Airflex Div. Fawick Corporation
LOCK-O-SEAL Parker Seal Co., Div. Parker Hannifin Corp.
LOCTITE American Sealants Co.
LOGANSQUARE Logansport Machine Co., Inc.
LONG-LOK Parker-Kalon Div., General American Transportation Corp.
LO-TORQ Republic Mfg. Co.
LOYD SCRUGGS Howard Industries, Inc.
LUBRITE Merriman Bros. Inc., Lubrite Div.
LUCITE E. I. du Pont de Nemours & Co. (Inc.)
LUSTER-ON The Chemical Corp.
LYSYN Sanborn Co., Industrial Div.
MARSDEN National Machine Products Co.
MARVINOL United States Rubber Co., Naugatuck Chem. Div.
MAY-O-MATIC Mayline Co., Inc.
MECATORN C. W. Torngren Co., Inc.
METALACE Maas & Walstein Co.
METAL-CAL C & H Supply Co.
MET-O-SEAL Parker Seal Co., Div. Parker Hannifin Corp.
MINI-JOINTS Falcon Div. General Thermodynamics Corp.
MITE George W. Dahl Co., Inc.
MONARCH Milsco Mfg. Co.
MONOBALL Southwest Products Co.
MORFLEX Morse Chain Co.
MOTOGEAR Link-Belt Company
MOTOREDUCER The Falk Corporation
MOX-TAPE Moxness Products, Inc.
MOYNO Robbins & Myers, Inc.
MYLAR E. I. du Pont de Nemours & Co., (Inc.)
NEG'ATOR Hunter Spring Co.
NEOGLIDE Chas. Bruning Co., Inc.
NETIC Magnetic Shield Div., Perfection Mica Co.
NITRALLOY Northern Ordnance, Inc.
NOPAK Galland-Henning Nopak Div.
NORPAK Square D Co.
NYAFLEX Dayco Corp., Dayton Dayflex Plastics Co. Div.
OILITE Amplex Div., Chrysler Corp.
OIL-MIST Alemite Div., Stewart-Warner Corp.
ORCO Eagle Picher Co., Ohio Rubber Co. Div.
ORTHANE Eagle Picher Co., Ohio Rubber Co. Div.
PALMETTO Greene, Tweed & Co.
PALNUT United-Carr Fastener Corp., The Palnut Co. Div.
PANEL CRAFT Milsco Mfg. Co.
PARAFLEX Dodge Mfg. Corp.
PATCHCORD AMP, Incorporated
PEMABRAZE Handy & Harman
PERMA-CODE W. H. Brady Co.
PERMA FOG Watts Regulator Co.
PERMA-NUT Tubular Rivet & Stud Co.
PIONEER Milsco Mfg. Co.
PLEXIGLAS Rohm & Haas Co.
POLYPENCO The Polymer Corp. of Penna.
POWERGRIP United States Rubber Co., Mechanical Goods Div.
PRE-PRINT Clearprint Paper Co.
PRES-SURE Buchanan Electrical Products Corp.
PRES SURE KOOL Associated Engineers, Inc.
PRO-FAX Hercules Powder Co., Inc.
PROTOMAKA Electrolab Printed Circuits Corp.
PROTOWIRING Electrolab Printed Circuits Corp.
PULLMORE Rockford Clutch Div. Borg-Warner
PUSHNUT United-Carr Fastener Corp., The Palnut Co. Div.
PYRONIL National Vulcanized Rubber Co.
QUICK-LOCK Simmons Fastener Corp.
RACINE Howard Industries, Inc.
RAWSON Formsprag Co.
REEVECOTE Vulcan Rubber Products Div., Reeves Bros., Inc.
REVERS-O-MATIC Funk Mfg. Co.
REV-LOCK Formsprag Co.
RIV-O-SEAL Parker Seal Co., Div. Parker Hannifin Corp.
ROAD KING Milsco Mfg. Co.
ROCKETTE Paragon-Revolute Div. Chas. Bruning Co., Inc.
ROKIDE Norton Company
ROLLPIN Elastic Stop Nut Corp. of America
ROTAC Ex-Cell-O Corp.
ROTO-LOCK Simmons Fastener Corp.
ROTOTIMER Farmer Electric Products Co., Inc.
ROUNDLINE Carter Controls, Inc.
ROYLAIR Airaterra
RULON Dixon Corp.
RUMACO The Ruthman Machinery Co.
Rx MET WaiMet Alloys Co.
SCHNORR Karl A. Neise, Inc.
SCHRADER Scovill Mfg. Co., A. Schrader's Son Div.
SCREW-LOCK Heli-Coil Corp.
SENTRY Milsco Mfg. Co.
SICON Midland Industrial Finishes Co.
SIL-FOS Handy & Harman
SINTEEL Mueller Brass Co.
SLIMSERT Rosan, Inc.
SOUTHCO South Chester Corp., Southco Div.
SPACEMAKER The Tomkins-Johnson Co.
SPAN-JET Wm. Steinen Mfg. Co. Industrial Nozzle Div.
SPHERCO Sealmaster Bearing Div., Stephens-Adamson Mfg. Co.
SPIN-LOCK Russell, Burdsall & Ward Bolt & Nut Co.
SPIROID Illinois Tool Works, Spiroid Div.
SPIROL C.E.M. Co.
SPLIT-FLOW Dynex, Inc.
SPRING-LOCK Simmons Fastener Corp.
SQUAIR The Tomkins-Johnson Co.
SQUARELINE Carter Controls, Inc.
STAKTUBE Stacor Equipment Co.
STAT-O-SEAL Parker Seal Co., Div. Parker Hannifin Corp.
STEELFLEX The Falk Corp.
STEMCO Stevens Mfg. Co., Inc.
STOPMASTER Rockwell-Standard Corp., Brake Div.
STRATO-THERM AMP, Incorporated
STREAMLINER Ozalid Div., General Aniline & Film Corp.
STRESSPROOF La Salle Steel Co.
STRIP-O-SEAL Parker Seal Co., Div. Parker Hannifin Corp.
SUPER-CISION Scully-Jones and Co.
SUPER HC The Gates Rubber Co.
SYNCHRON Hansen Mfg. Co., Inc.
SYNCLINAL Marvel Engineering Co.
SYNPRO-TEX Torq Engineered Products, Inc.
TAN-JET Wm. Steinen Mfg Co. Industrial Nozzle Div.
TAPER-LOCK Dodge Mfg. Corp.
TEC Handy & Harman
TEC-Z Handy & Harman
TENSILOCK Russell, Burdsall & Ward Bolt & Nut Co.
TERMIN-O-SEAL Parker Seal Co., Div. Parker Hannifin Corp.
THERMOMETAL H. A. Wilson Div., Engelhard Industries, Inc.
THERMOSWITCH Fenwal, Inc.
THRIFT KING Milsco Mfg. Co.
TIMING United States Rubber Co., Mechanical Goods Div.
TITAN Cerro de Pasco Corp., Titan Metal Mfg. Co. Div.
TORQUE-ARM Dodge Mfg. Corp.
TRI-SURE Buchanan Electrical Products Corp.
TROYFELT Troy Blanket Mills (Industrial Products Div.)
TRUARC Waldes Kohinoor, Inc.
TRUFLEX Metals & Controls Div., Texas Instruments, Inc.
TRU-LAY American Chain & Cable Co., Inc., Automotive & Aircraft Div.
TRU-LOC American Chain & Cable Co., Inc.
TWO-WAY MacLean-Fogg Lock Nut Co.
TYCHOWAY Scully-Jones and Co.
TYSON SKF Industries, Inc.
UNI-TORQUE MacLean-Fogg Lock Nut Co.
UTILITUBE Aluminum Company of America
UTILITY Milsco Mfg. Co.
VARI DRAULIC Hydraulics, Inc.
VARY-TALLY Veedor-Root, Inc.
VEMCO Alvin & Co., Inc.
VENTORQUE Fawick Airflex Div. Fawick Corporation
VIBRIN United States Rubber Co., Naugatuck Chem. Div.
VICALLOY Arnold Engineering Co.
WAGNER Allied Research Products, Inc.
WHITE LIGHTS Stocker & Yale
WHIZ-LOCK MacLean-Fogg Lock Nut Co.
WILBOW The Williams-Bowman Rubber Co.
WOODMASTER Stacor Equipment Co.
W-POINT Parker-Kalon Div., General American Transportation Corp.
ZYTEL E. I. du Pont de Nemours & Co. (Inc.)

ALPHABETICAL INDEX TO ADVERTISERS

—A—

A & A Mfg. Co., Inc. ... 550
AMP, Inc. ... 461
Acme Chain Corp. ... 255
Acme Electric Corp. ... 482
Aero Research Instrument Co., Inc. ... 482
Aeroquip Corp. ... 527
Aetna Ball & Roller Bearing Co., Div., Parkersburg-Aetna Corp. ... 293
Airaterra ... 552
Airborne Accessories Corp. ... 226
Airmatic Valve, Inc. ... 514
Alden Products Co. ... 51
Allegheny Ludlum Steel Corp. ... 94
Allen Mfg. Co. ... 367
Allied Research Products, Inc. ... 159
Almo Manifold & Tool Co. ... 549
Aluminum Co. of America ... 102
Alvin & Co., Inc. ... 52
Amchem Products, Inc., Metalworking Chemicals Div. ... 126-127
American Cast Iron Pipe Co. ... 101
American Chain & Cable Co., Inc., Tru-Loc Assemblies ... 328
American Insulator Corp. ... 157
American Sealants Co. ... 365
Anaconda Metal Hose Div., American Brass Co. ... 318
Anchor Coupling Co., Inc. ... 518
Anker Holth Div., Wellman Engineering Co. ... 533
Arkwright Finishing Co. ... 46
Arnold Engineering Co. ... 462
Art Wire & Stamping Co. ... 196
Associated Engineers, Inc. ... 522
Associated Spring Corp. ... 296
Auburn Mfg. Co. ... 324, 328
Automatic Electric Sales Corp. ... 456-457
Automatic Switch Co. ... 523
Automotive & Aircraft Div., American Chain & Cable Co., Inc. ... 306
Avdel, Inc. ... 360

—B—

Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div. ... 477
Baldwin-Lima-Hamilton Corp., Standard Steel Works Div. ... 91
Barber-Colman Co. ... 404-405
Baush Machine Tool Co. ... 231
Bearium Metals Corp. ... 100
Beaver Precision Products, Inc. ... 268
Bellofram Corp. ... 545
Benton Harbor Engineering Works, Inc. ... 525
Bird & Co., Inc., Richard H. ... 334
Blaw Knox Co. ... 186
Bodine Electric Co. ... 418
Borg & Beck Div., Borg-Warner Corp. ... 253
Borg-Warner Corp. ... 227
Boston Gear Works ... 225
Brady Co., W. H. ... 486
Brevel Products Corp. ... 426
Brooks & Perkins, Inc. ... 191
Bruning Co., Inc., Charles ... 53
Brush Beryllium Co. ... 84
Buchanan Electrical Products Corp. ... 475, 490

—C—

C & H Supply Co., Metal-Cal Div. ... 190
C. E. M. Co., Inc. ... 368
Cambridge Wire Cloth Co. ... 298
Camloc Fastener Corp. ... 358
Cannon Electric Co. ... 471
Carr Fastener Co., Div. of United-Carr Fastener Corp. ... 371
Carter Controls, Inc. ... 537
Cellusuede Products, Inc. ... 158
Chandler Products Corp. ... 382
Chassis-Trak, Inc. ... 304
Chemical Corp. ... 156
Chemiquip Co. ... 552
Cherry Electrical Products Corp. ... 472
Chicago Lock Co. ... 332
Chrysler Corp., Amplex Div. ... 297
Circle Seal Products Co., Inc. ... 552
Clad-Rex Corp., Div. of Simoniz Co. ... 130
Clearprint Paper Co. ... 47
Comar Electric Co. ... 464
Cone-Drive Gears Div., Michigan Tool Co. ... 260-261
Continental Diamond Fibre Co., Subs., Budd Co. ... 146
Corning Glass Works ... 125
Coto-Coil Co., Inc. ... 489
Cramer Controls Corp. ... 458
Crane Plastics, Inc. ... 158
Crouse-Hinds Co. ... 463
Crown Gear Div., Harrington & Richardson, Inc. ... 266
Curtis Universal Joint Co. ... 230
Cutler-Hammer, Inc. ... 448-449

—D—

Dahl Co., Inc., George W. ... 554
Dakota Engineering, Inc. ... 472
Danielson Mfg. Co. ... 154
Dayton Dayflex Plastics Co., Div. of Dayco Corp. ... 540
De Laval Steam Turbine Co. ... 246-247
Denison Engineering Div., American Brake Shoe Co. ... 528-529
Dialight Corp. ... 483
Dimco-Gray Co. ... 320, 372
Dixon Corp. ... 128
Dodge Mfg. Corp. ... 264-265
Doerr Electric Corp. ... 427
Duff-Norton Co. ... 257
du Pont de Nemours & Co., (Inc.), E. I., Film Dept. ... 142
du Pont de Nemours & Co., (Inc.), E. I., Polychemicals Dept. ... 123-124
du Pont de Nemours & Co., (Inc.), E. I., Textile Fibers Dept. ... 138
Durametallic Corp. ... 323
Durant Mfg. Co. ... 465
Durez Plastics Div., Hooker Chemical Corp. ... 134-135
Dynamic Gear Co., Inc. ... 332
Dynex, Inc. ... 517
Dynisco, Inc. ... 486

—E—

Eastman Mfg. Co. ... 524
Elastic Stop Nut Corp. of America ... 363, 377, 482
Elco Tool & Screw Corp. ... 373
Electrical Industries Div., Philips Electronics, Inc. ... 459
Electro-Flex Heat, Inc. ... 472
Electro Switch Corp. ... 480
Electrolab Printed Electronics Corp. ... 488
Electronic Processes Corp. of California ... 475
Emcor Ingersoll Products Div., Borg-Warner Corp. ... 48
Engelhard Industries, Inc. ... 86-87
Equitable Engineering Co. ... 241
Ex-Cell-O Corp., Rotac Div. ... 541
Excelsior Leather Washer Mfg. Co., Inc. ... 536

—F—

Fairbanks, Morse & Co., Magneto & Engine Accesories Div. ... 219
Fairfield Mfg. Co., Inc. ... 262
Falcon Div., General Thermodynamics Corp. ... 240
Falk Corp. ... 232
Farmer Electric Products Co., Inc. ... 480
Faultless Caster Corp. ... 319
Fawick Airflex Div. of Fawick Corp. ... 250-251
Federal-Mogul Div., Federal-Mogul-Bower Bearings, Inc. ... 316
Felters Co. ... 122
Fenwal, Inc. ... 484
Ferguson Machine Corp., Subs., Universal Match Corp. ... 236
Flanders Filters, Inc. ... 190
Flexonics Corp., Bellows & Industrial Hose Div. ... 299
Foote Bros. Gear & Machine Corp. ... 259
Ford Motor Co., Industrial Engine Dept. ... 414
Formica Corp., Subs., American Cyanamid Co. ... 160
Formsprag Co. ... 224
Funk Mfg. Co. ... 254
Furnas Electric Co. ... 420
Fusite Corp. ... 455

—G—

Galland-Henning Mfg. Co., Nopak Div. ... 551
Gamble Brothers, Inc. ... 140
Garlock, Inc. ... 520-521
Garrett Co., Inc., George K. ... 369
Gast Mfg. Corp. ... 538
Gates Rubber Co. ... 243
Gear Specialties, Inc. ... 242
General Aniline & Film Corp., Ozalid Div. ... 45
General Electric Co., Miniature Lamp Dept. ... 473
General Findings & Supply Co., Industrial Div. ... 487
Gillen Co., John, Subs., Stanray Corp. ... 329
Gilman, Inc., Russell T. ... 308
Gleason Works ... 230
Globe Industries, Inc., Supermet Div. ... 196
Goshen Rubber Co., Inc. ... 378
Graham Transmissions, Inc. ... 266
Graphite Metallizing Corp. ... 322, 460
Greene, Tweed & Co. ... 543
Grip Nut Co. ... 366

—H—

Halogen Insulator & Seal Corp. ... 548
Handy & Harman ... 356
Hansen Mfg. Co., Inc. ... 422
Harrington & King Perforating Co., Inc. ... 188
Harrison Mfg. Co. ... 331
Hart Mfg. Co. ... 478
Hassall, Inc., John ... 384
Haveg Industries, Inc., Taunton Div. ... 139
Heli-Coil Corp. ... 374
Hercules Powder Co., Inc., Cellulose Products ... 136-137
Hexcel Products, Inc. ... 78
Hilliard Corp. ... 220
Horsburgh & Scott Co. ... 240
Hoskins Mfg. Co. ... 79
Hotwatt, Inc. ... 481
Howard Industries, Inc. ... 424-425
Hubbell, Inc., Harvey, Machine Screw Dept. ... 374
Huck Mfg. Co. ... 379
Hudson Tool & Die Co., Inc. ... 451
Hunter Spring Co. ... 322, 428
Hyatt Bearings Div., General Motors Corp. ... 294-295
Hydraulics, Inc. ... 266
Hydromatics, Inc. ... 548

—I—

Imperial Brass Mfg. Co. ... 512
Industrial Electronic Engineers, Inc. ... 488
Industrial Retaining Ring Co. ... 366
Industrial Sapphire Co. ... 325
Instrument Specialties Co., Inc. ... 292
International Packings Corp. ... 510

—J—

Janco Corp. ... 464
Jarvis & Jarvis, Inc. ... 330
Jergens Tool Specialty Co. ... 322
Johnson Bronze Co. ... 233

(Continued on page 23)

To get additional information on products and services offered in this DESIGN DIGEST

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ALPHABETICAL INDEX TO ADVERTISERS *(Continued from page 16)*

Jones & Laughlin Steel Corp., Stainless & Strip Div. 97
Joyce Cridland Co. 254

—K—

Kaiser Aluminum & Chemical Sales, Inc. 187
Kaupp & Sons, C. B. 183
Kennametal, Inc., Metalworking Div. . 99
Keystone Carbon Co. 181
Keystone Mfg. Co. 197
Kirk & Blum Mfg. Co. 307
Kohler Co., Engine Div. 419
Koppers Co., Inc., Plastics Div. ..132-133
Kurz-Kasch, Inc. 466

—L—

L & L Mfg. Co. 542
LaSalle Steel Co. 85
Leach & Garner Co., Industrial Div. .. 487
Leiman Brothers, Inc. 536
Lenz Co. 534, 536, 553
Lewis Co., G. B. 156
Lignum-Vitae Products Corp. 129
Link-Belt Co. 248-249
Lock Thread Corp. 382
Logansport Machine Co., Inc. 530
Lowell Wrench Co. 324
Lucas-Milhaupt Engineering Co. 384
Lundey Associates 481

—M—

McGill Mfg. Co., Inc. 300-301
M-D Blowers, Inc., Subs. of Miehle-Goss-Dexter, Inc. 321
Maas & Waldstein Co. 147
MacLean-Fogg Lock Nut Co. 375
Madison-Kipp Corp. 189
Malleable Castings Council 194-195
Marsh Instrument Co., Div. of Colorado Oil & Gas Corp. 326
Marvel Engineering Co. 532
Masland Duraleather Co., The 149
Mayline Co., Inc. 52
Mercury Clutch Div., Automatic Steel Products, Inc. 256
Merriman Brothers, Inc. Lubrite Div. . 327
Merriman Brothers, Inc., Powdered Metal Div. 188
Michigan Tool Co., Cone-Drive Gears Div. 260-261
Michigan Wire Cloth Co. 326
Micro Switch, a Div. of Minneapolis-Honeywell Regulator Co. 470
Midland Industrial Finishes Co. 128
Midwest Rubber Co. 158
Miller Electric Co. 474
Miller Fluid Power Div., Flick-Reedy Corp. 511
Milsco Mfg. Co. 320
Milwaukee Cylinder Co., Div. of L & M Machine Co. 548
Molded Fiber Glass Co. 129
Molon Motor & Coil Corp. 428
Moore, Inc., George W. 380
Morse Chain Co., A Borg-Warner Industry 263
Moxness Products, Inc. 155
Mueller Brass Co. 193

—N—

National Band & Tag Co. 488
National Machine Products Co. 380
National-Standard Co. 89
National Vulcanized Fibre Co. 143
Neise, Inc., Karl A. 324
New Departure Div., General Motors Corp. 228
New Hampshire Ball Bearings, Inc. 310
Nicholson & Co., W. H. 333
Northern Ordnance, Inc., Subs. of Northern Pump Co. 553
Norton Co., Refractories Div. 131
Nylomatic Corp. 330

—O—

Ohio Nut & Bolt Co. 378
Ohio Rubber Co. 150-151
Omark Industries, Inc. 359
Orange Roller Bearing Co., Inc. 313

—P—

Palnut Co., Div., United-Carr Fastener Corp. 383
Paragon-Revolute Div. of Charles Bruning Co., Inc. 55
Parker-Kalon Div., General American Transportation Corp. 364
Parker Seal Co., Div., Parker-Hannifin Corp. 303
Pathon Mfg. Co. 544
Penn Engineering & Mfg. Corp. 357
Perfection Mica Co., Magnetic Shield Div. 478
Pittsburgh Steel Co. 92-93
Plan Hold Corp. 56
Pollak Corp., Joseph 474
Polo Plastics Co. 160
Polymer Corp. of Pennsylvania 148
Post Electronic Products Div., Reid Brothers Co., Inc. 483
Potter & Brumfield, Inc., Div., American Machine & Foundry Co. .. 450
Precision Extrusions, Inc. 98
Precision Rubber Products Corp. 309
Presin Co. 490

—R—

Rampe Mfg. Co. 256
RapiDesign, Inc. 54
Relay Sales, Inc. 466
Reliance Electric & Engineering Co. .. 421
Republic Mfg. Co. 550
Republic Steel Corp. 80-81
Reuland Electric Co. 416-417
Reynolds Metals Co., Industrial Products Div. 76-77
Riverside-Alloy Metal Div., H. K. Porter Co., Inc. 90
Rivett Lathe & Grinder, Inc. 516
Robbins & Myers, Inc. 409, 423, 519
Rockford Clutch Div., Borg-Warner Corp. 229
Rockwell-Standard Corp., Brake Div. . 302
Rockwell-Standard Corp., Transmission & Axle Div. 244
Rogan Brothers 156
Rohm & Haas Co. 141
Roper Hydraulics, Inc. 515
Rosan, Inc. 381
Russell, Burdsall & Ward Bolt & Nut Co. 376
Ruthman Machinery Co. 543

—S—

SKF Industries, Inc. 315
Saginaw Steering Gear Div., General Motors Corp. 237
Sanborn Co. 468
Sandusky Foundry & Machine Co. 180
Schrader's Son, A., Div., Scovill Mfg. Co., Inc. 539
Scott, Inc., H. H. 54
Scully-Jones & Co. 267
Sier-Bath Gear & Pump Co., Inc., Gear Div. 218
Simmons Fastener Corp. 370
Sinko Mfg. & Tool Co. 154
Soss Mfg. Co. 372
South Chester Corp., Southco Div. . 354-355
Southwest Products Co. 308
Speed Selector, Inc. 256
Spiroid Div., Illinois Tool Works ... 221
Sprague Engineering Corp. 526
Square D Co. 406-407
Stacor Equipment Co. 52, 54
Standard Electrical Tool Co., Precision Spindle Div. 320
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp. 91
Statham Instruments, Inc. 485
Steinen Mfg. Co., William 542
Stephens-Adamson Mfg. Co., Spherco Bearings & Rod Ends Div. 329
Stevens Mfg. Co., Inc. 453
Steward Mfg. Co., D. M. 160
Stewart Corp., F. W. 252
Stewart-Warner Corp., Alemite Div. . 311
Stocker & Yale, Inc. 323
Stokes Molded Products Co. 192
Stoner Rubber Co., Inc. 327
Strataflo Products, Inc. 534
Sundstrand Hydraulics Div., Sundstrand Corp. 535
Sunset Line & Twine Co. 158
Superior Carbon Products, Inc. 476
Synthane Corp. 182

—T—

TA Mfg. Corp. 489
Tecumseh Products Co., Engine Div. .. 426
Texas Instruments Incorporated Metals & Controls Division 83
Titan Metal Mfg. Co. 96
Toledo Commutator Co. 428
Tomkins-Johnson Co. 513
Torngren Co., Inc., C. W. 197
Torq Engineered Products, Inc. 479
Torrington Mfg. Co. 317
Triangle Mfg. Co. 324
Trombetta Solenoid Corp. 469
Troy Blanket Mills 144
Tru-Seal Div., Flick-Reedy Corp. 550
Tubular Rivet & Stud Co. 362
Tuthill Pump Co. 531
Twin Disc Clutch Co. 238

—U—

Ucinite Co., Div., United-Carr Fastener Corp. 326
Ulanet Co., George 479
Union Carbide Corp., Union Carbide Plastics Co., Div. 145
United Electric Controls Co. 464
U. S. Radium Corp. 454
U. S. Rubber Co., Mechanical Goods Div. 222-223
U. S. Rubber Co., Naugatuck Chemical Div. 153
Universal Electric Co. 415

—V—

V. & E. Mfg. Co. 52
Veeder-Root, Inc. 312
Vellumoid Co. 546
Vulcan Rubber Products Div., Reeves Bros., Inc. 154

—W—

Wabash Metal Products Co. 304
Wagner Electric Corp. 410-411
WaiMet Alloys Co. 82
Waldes Kohinoor, Inc. 361
Walker Co., George 490
Warner Automotive Div., Borg-Warner Corp. 245
Warrick Co., Charles F. 466
Watlow Electric Mfg. Co. 467
Watts Regulator Co. 549
Waukesha Foundry Co., Foundry Div. 185
Webster Electric Co., Oil Hydraulics Div. 547
Western Felt Works 152
White Dental Mfg. Co., S. S., Industrial Div. 314
Whitney Chain Co., Subs. of Foote Bros. Gear & Machine Corp. 258
Wiegand Co., Edwin L. 452
Williams-Bowman Rubber Co. 190
Willys Motors, Inc., Industrial Engine Dept. 408
Winsmith, Inc. 234-235
Wisconsin Motor Corp. 413
Winterburn Mfg. Co. 486
Wolverine Tube Div., Calumet & Hecla, Inc. 95
Worcester Valve Co. 305

—Z—

Zero Mfg. Co. 488

WHAT WOULD HAPPEN IF ALL ADVERTISING STOPPED?

Stores would begin cancelling orders. Very quickly, manufacturers would close down plants and lay off millions of employees. Volume production would be a thing of the past . . . and so, prices would rise fast.

Within a week most radio and television stations would close up shop for lack of revenue. The ability of many newspapers and magazines to perform their full, vital functions would be seriously impaired. And the cost per copy would zoom for those that tried to keep running only on circulation revenues.

This alternative to advertising can hardly be the goal of the critics of advertising. Without advertising our national economy, our national *life*, would be bleak indeed. In many ways, advertising is the *power plant* of our society.

MORE CUSTOMERS FOR MORE PRODUCTS—American creative genius and wonderful ability for organization have resulted in a tremendous flow of goods of all kinds. This creates a crucial need for *masses* of people anxious, willing and able to *buy* and *consume* these goods. Only a society with a constantly *rising* standard of living can provide the customers. These customers have to be sought, taught and often *persuaded* to move higher in the scale of living. This is the job of advertising.

Advertising not only gives people news about new products, but provides the *urge* for people to own and enjoy these products. The wider and deeper the penetration of our products into the life of America, the greater the need for more production. This means more jobs. More jobs mean more people able to enjoy what we make. More people buying means more, still more production. And so on and so on. The result is that more Americans can enjoy more of the fruits of their labor than people in any country anywhere in the world can enjoy theirs.

ADVERTISING LOWERS PRICES—Does advertising raise the cost of goods? On the contrary. Through newspapers, television, magazines, radio and billboards, an advertiser can talk to a prospect for a tiny fraction of a cent. Advertising is the quickest and cheapest way of reaching large numbers of people. It enables the advertiser to reach his market (customers) inexpensively and thus increase his total production, thereby reducing the cost of making and selling each unit.

THE CULTURAL EFFECTS OF ADVERTISING—It's because of *advertising* that our mass media of communication can afford to command the finest talent for bringing to the American people information, stimulation, entertainment and education which in other countries are available to just a very few people.

Advertising makes its cultural contribution in another way. Advertising is in large measure responsible for better living, less drudgery, more leisure for more people. This creates opportunities for intellectual and spiritual activities equaled in few, if any, other countries. While millions and millions of dollars are being spent by Americans for cars, boats, sports equipment and the paraphernalia of leisure, there is a growing *hunger* for improvement of the mind and for aesthetic enjoyment.

WHAT ARE THE "NEEDS" OF THE PEOPLE?—Critics of advertising sometimes indict it for creating dissatisfaction in people's minds with what they have, and persuading and cajoling them into buying what they neither need nor want. But what are "needs?" The "needs" of people in undeveloped countries are not the same as our needs. Our needs of 50 years ago are not the same as they are today. We don't actually "need" electric razors, electric refrigerators, vacuum cleaners, television sets, shampoos, beauty treatments, packaged goods, or even automobiles. But would the critics of advertising stop encouraging people to want a better life? Would they have the millions of people who create, produce, and market the so-called "non-essentials" thrown out of jobs? Do they want us to go back to the more primitive living of other countries?

ADVERTISING—PUBLIC SERVANT—Frequently, the advertising industry is called on to direct public-service jobs—for the Government as well as for private public-service organizations. This it does through the Advertising Council, a nonprofit organization supported by American business and advertising media. Here's what President Eisenhower said to the Advertising Council in Washington several months ago:

"For eighteen years you have been stimulating the nation's conscience in areas where the voluntary work of great numbers of people has been necessary in order to promote worthwhile causes. I know you have been in such fields as conservation, organized charities, safety, prevention of accidents, and more recently in giving your efforts to the job of pointing out to our people the need for self-discipline if we are to avoid debasement of our currency and prevent inflation.

"And I think no other body has done more in this regard in trying to inform America across the board of these things than The Advertising Council."

Prepared in the interest of wider understanding of advertising with the assistance of the Bureau of Advertising, ANPA

SECTION A

GENERAL ENGINEERING

Design Abstracts 26

Copying Methods for the Engineering Office 28

Ten Commandments for Design Reliability
by B. Bradford Richardson 30

Noisy Sound
by Myron M. Kawa, Jr. 32

Tabulated: Test-chamber Refrigerants
by Dale J. Missimer 34

Basic Information on Air Filtration 35

When Plastics Burn What Are the Hazards from Toxic Fumes?
by E. H. Coleman 40

DESIGN ABSTRACTS

ENGINEERING IN THE EVOLUTION OF PRODUCTS

Analysis of the effects of vesting various sections of a manufacturing organization with responsibility for the initiation and development of new products is made and reasons for placing it in the hands of the research and engineering groups are given. Working relationships between research, engineering and industrial design personnel are also discussed. A standard procedure for product development is outlined, based on the author's suggestions for centralizing control in research and engineering.

"Engineering," W E Mahaffey, Whirlpool Corp. Presented at Conference on The Evolution of Products, Oct 26-29, 1958, sponsored by Center for Design Studies, Div of Institute for Contemporary Art, 230 The Fenway, Boston 15.

*

Design Piracy

Supposed advantages of piracy, dangers, and other considerations (aside from moral questions) are discussed.

"Design Piracy—Unethical or Foolish?" James Warren, Industrial Design Professor, National College of Arts, Lahore, Pakistan. Design Engineering, Nov '59, 481 University Ave, Toronto 2, Ont.

*

Which Secrets Should Be Kept?

Here are four positive reasons for being less reticent in matters of interest to the technical press:

A feature article in a leading business publication enhances the stature of the individual who wrote it; a company mention in the by-line or body of an article helps to establish it as a source of sound technical data; assuming that secrets indeed are hard to keep, why not take the credit for being the first to figure things out? If you wait until the competition gets your know-how, you may be sure that they will rove more alert to its publicity potential, and will exploit it to the fullest; a company that consistently appears in the business press with new ideas, new developments, or new methods comes to the attention of engineers who depend on these publications to keep them up-to-date with the latest state of the art.

"I've Got A "Secret"" L R Grief, Grief Associates, Inc. Plastics Technology, Oct 1959, 630 Third Ave, New York 17.

*

Criteria for Reliability

Design criteria for reliability discussed in this paper include concepts of environments, strengths, strength-environment separation factors, allocation of unreliability values to elements of a system. Possible design procedures which result from three different types of testing are discussed. Various criteria concepts and techniques for evaluating reliability are demonstrated with an example based on a mechanical element.

"Reliability Design Criteria," Brown, Love and White, Hughes Aircraft Co; SAE paper 101V, SAE, 485 Lexington Ave, New York 17.

*

British Technical Sources Listed

A quick reference guide to the main sources of information useful to the designer has been specially compiled. It is presented in five pages, alphabetically arranged and tabulated.

"Where to Find Technical Information," Engineering Materials and Design, March 1960, Drury House, Russell St, London, WC 2, England.

*

Biomagnetics

Proposals that space vehicles be propelled by means of ion accelerators, fusion reactors, photon motor, and other teratogenic devices often involve the potential use of strong magnetic fields. Experimental evidence suggests that magnetic fields produce a variety of effects upon living matter; however, these facts are not well publicized. In this paper some of the findings of published studies are summarized with the intent of stimulating interest in the domain of biomagnetics, and the need for caution is pointed out when humans are subjected to the influence of powerful magnetic fields.

"Biomagnetics," Harold S. Alexander, Human Factors Engineering Missile Division, North American Aviation, Inc. Proceedings of the Institute of Environmental Sciences, Box 191, Mt Prospect, Ill.

*

Wear Behavior

Discusses possibility of establishing suitable values for the comprehending and expressing of values for effects of wear on various types of parts and materials subjected to abrasive and similar conditions. Data are drawn from earlier work on a variety of products, including automobile tires, steel wheels, tools.

"Basic Questions of Wear", Wilhelm Spath. Verein Deutscher Ingenieure, No. 199, West Germany. Order translation from SLA Translation Center, John Crerar Library, 86 E Randolph St, Chicago 1.

*

Testing of Fiber Properties

Some of the techniques for testing such mechanical properties of both natural and synthetic fibers as load to rupture, deformation, repeated stress, abrasion resistance. Some curves are included that are typical of results obtained in the testing procedures discussed.

"Mechanical Properties of Textile Materials," E. J. Stavrakas, Fabric Research Laboratories Inc. Mechanical Engineering, March '60, 29 W 39 St, New York 18.

*

Engineering Management

Discusses the peripheral problems, responsibilities and techniques that the manager of engineering must understand, beyond the knowledge and training immediately associated with

technological work programs. Among the fields which may touch upon the engineering administrator's work are: sociology, public administration, political science, psychology, law, economics, accounting, physiology and biology. A listing of specific work functions and their relationship to the management of engineers is included.

"Peripheral Professional Problems of Engineering Management," C. F. Savage, General Electric Co. Electrical Engineering, Dec '59, 33 West 39th St, New York 18.

*

System Analysis

Discusses systems and systems analysis from three standpoints: historical (from Newton and Laplace to the present), philosophical (describes parallel between learning process and the systems viewpoint) and practical (specific examples of systems are presented).

"Constructs, Models and Systems," Quackenboss and Butterworth, General Motors Corp. SAE paper 113C. SAE, 485 Lexington Ave, New York 17.

*

Style Manual for Technical Reports

Contents, organization and procedure for issuing company-wide guide for preparation of technical reports are discussed. Which types of style decisions should be compulsory and which left to the individual author's decision or personal writing style are also included.

"Building An Organization Style Manual for Technical Reports," Ethaline Cortelyou, Aerojet-General Corp. Presented at American Chemical Society Div of Chemical Literature Meeting, Sept 13-18. ACS, 1155-16 St, NW, Washington 6, DC.

*

Why Should Engineers Vote?

How and why engineers should apply the engineering approach to political and civic affairs in their individual communities. Specific suggestions as to the forms participation by engineers might take are given.

"Why Should Engineers Vote?", J W Barker, Research Corp. Mechanical Engineering, Aug 1959, 29 W 39 St, New York 18.

*

Do Standards Stifle Creativity?

In this discussion of the interrelationship among engineering creativity and standardization of procedures, components and other design factors, various authorities are cited and their findings and opinions evaluated. In a listing at the end of the article, the principal characteristics of the engineering work involved in various activities (such as applied research, R & D for a specific product, quantity production) are presented.

"Standardization and Creativity," Rowen Gile, W L Maxon Corp. Magazine of Standards, March '60, 10 E 40 St, New York 16.

*

Multivariable Experimentation

As an aid to studies of complex systems, a non-technical description is given of some of the statistical design techniques that have been developed during the last 15 years. Discusses selection of the variables in a given experiment, together with methods of determining the best experimental techniques. Bibliography included.

"Multivariable Experimentation," W. J. Youden, National Bureau of Standards; SAE Paper 116A. SAE, 485 Lexington Ave, New York 17.

*

Industrial Communications

Management is responsible for setting objectives and for seeing that they are carried out. Successful managers are able to communicate effectively. Using a man-machine analogy, the author shows how successful communications (input) can lead to greater employee response (output). Improved productivity and better morale result.

There are 10 sound rules that lead to improved communications. The objective of these rules is to make people comply. The rules are summarized.

"Industrial Communication . . . An Engineering Approach," James H. Green, Purdue University, Lafayette, Ind. Tool Engineer, March '60, 10700 Puritan Avenue, Detroit 38.

*

Administering R & D

Methods for improving results obtained from research and development programs are discussed. Includes such aspects as planning, operations, measurement and analysis of progress budgeting and finances.

"The Administration of Research and Development Projects," Howard L. Mills, General Electric Co; ASME paper 59-A-246. ASME, 29 W 39th St, New York 18.

*

Testing Materials at Low Temperatures

Techniques developed for evaluating the mechanical properties of materials at temperatures between −423 and −452 F are described. Included are hardness, impact, tensile, fatigue, torsion tests and strain measurement, conducted both in liquid hydrogen and cold helium gas.

"Notes on Mechanical Testing Techniques at Very Low Temperatures." Defense Metals Information Center Memorandum 43. Battelle Memorial Institute, Columbus 1, Ohio.

*

Physiological Responses to Mental Tasks

This is a report of a study of the variations in several types of physiological responses to a systematic program of mental tasks of varying difficulty.

"Effects of Mental-task Difficulty on Physiological Response," Glassner and Peters, Engineering paper 848. Douglas Aircraft Co, El Segundo, Calif.

COPYING METHODS FOR THE ENGINEERING OFFICE

Tabulated facts about 6 systems that will help you find the right answer when choosing among the many methods now available.

COPYING-MACHINE METHODS, REQUIREMENTS AND

	Method	Speed	Max copy size (approx)
1. DIAZO	Translucent original, sensitized copying paper. Ammonia vapor or liquid developer.	Usable copy is delivered after 10 or more secs.	54 in. width; length continuous if required.
2. BLUEPRINTING (Also Brownprinting)	Translucent original, sensitized copying paper. Developing fluid followed by water wash.	10 to 120 secs or more exposure. (Drying after washing may increase time considerably for usable copy.)	Same as for diazo. Developing and washing can be done automatically.
3. PHOTOCOPYING (Also Known as "diffusion Transfer" Process)	Reflex principle: Original face to face with negative sheet, light-colored areas on original reflect light back to negative. After exposure this negative placed face to face with positive paper and exposed in printer. Developed positive copy is peeled from negative.	Approx. 20 secs per copy, 7 secs for one-step machines.	Some up to 18 in. wide, any length.
4. DYE TRANSFER	Similar to photocopying except image "transfers" to plain bond paper, which is then peeled from negative.	From 30 to 60 secs for first copy; 2 to 3 secs for additional copies, up to 5 or 6, then new negative must be made.	Up to 10 in. x 18 in.
5. HEAT TRANSFER	Heat-sensitive copy-paper placed coating-side-up on original. Dark areas on original reflect infrared light which, in turn, converts coating on copy paper into dark areas thus producing positive copy.	Approx. 5 secs.	Generally 8½ in. x 11 in.; 18 in. x 24 in. when original is microfilm.
6. ELECTROSTATIC	Xerography: "Negative" is an electrically charged, selenium coated plate. Image of original material is projected through lens onto metal plate. Charge is discharged where light hits so when opposite-polarity ink or powder is cascaded over plate still-charged character-image on plate attracts ink. This negative image is then transferred to plain bond or sulphite paper and made permanent by exposure to heat. Electrofax: Same as above but coated paper used instead of metal plate. This paper becomes the copy.	6 copies per min for the 9 in. x 14 in. copy-size machine; 20 ft per min by 11 in.- and 24 in.- wide for continuous-copy machines. The 24-in. machine requires micro-film as original copy; the 11-in. machine takes original copy up to 11 in. wide.	Flat-plate machine can reduce 36 in. x 24 in. drawing to 11 in. x 17 in. copy. Can enlarge to this size also. Setup is similar to conventional photography except special sensitized plate is processed differently.

Every engineer has to decide from time to time what the best method is for copying drawings or other communications material. Layouts and detail drawings are no longer the sole products of his work that need copying; copies of mathematical analyses, test results, rough design-sketches, etc., are often needed to speed communication. The most efficient and economic way is not always the fastest or the cheapest.

The following table of copying methods will help steer a way through to the right choice.

Spirit duplicating, photography, photo-offset and letterpress printing methods have not been covered since they are generally well known.

MICROFILM COPYING

Copies up to 18 in. by 24 in. direct from microfilm can be produced by some machines. This is a comparatively recent development and should certainly be considered in any office planning. The machines use the same basic methods as those described in the table but they require microfilm originals. This, of course, will entail extra equipment with which to obtain the microfilm copy of the original drawings.

Acknowledgement for much of the material appearing here is made to: Charles Bruning Co, Inc, Copease Corporation, Verifax Div of Eastman Kodak, Thermo-Fax Div of Minnesota Mining & Manufacturing Co, and the Haloid Zerox Co.

RESULTS

Copy cost (for 8½ in. x 11 in. copies)	Most Suitable Original	Appearance	Number of Copies	Remarks
Approx. 1c per letter size copy. (Material cost only.)	Line drawings, sketches, on one side of translucent material, half-tone neg's (with special paper).	Positive: Black or colored line on white or tinted stock.	Unlimited—translucent positives (intermediates) can be made to speed up production.	Fast, inexpensive copying of all kinds. Limited only by quality of original translucent sheet. Basic for drafting offices.
Same as for Diazo	Same as for diazo except not suitable for half-tones.	Negative—white line on blue or brown background.	Unlimited.	Very low-cost per copy. Equipment widely available.
From 3 to 10 cents per copy. Median seems to be about 8 cents.	Any original with good contrast. Can produce copy on both sides of print if desired	Good to excellent for line copy; halftone, fair.	Depends only on resistance to handling of original material.	"On-the-spot," high-quality copying of all kinds of artwork. Flat-bed machine can copy pages from bound book. In some machines developing solutions must be removed at end of day. May require more subdued light than usual.
First copy 10 cents, additional copies to 5 or 6 about ½ cent each for material.	Same as for photocopying.	For line work and type: First copy often quite as good as photo-copying. Halftones: Lack detail. Quality falls off fast after 4 or 5 copies have been taken off negative.	Inexperienced operator—4 or 5, expert—10 to 12 for each negative.	Can reproduce copy onto both sides of ordinary bond paper or regular office forms. Subdued light desirable. Flat-bed copiers availabe.
Just over 5 cents each.	Any material written or printed with a carbon or metallic base material. (Preferably on one side only when original is translucent).	Copy material is flimsy, almost translucent paper with pinkish or white background, or can be bond-type paper.	No limit—one per copy-paper.	Copies remain sensitive to heat, can become blackened if kept in hot place, e.g. in sunlight. Paper that does not remain sensitive is now available.
Average when rented 5c per copy (based on 10,000 copies per month). When owned, approx. 1c pe rcopy for materials.	Same as for photocopying.	Similar to photocopy. Xerography reproduces on bond paper and similar materials.	No limit.	Also using Electrofax principle is a recently introduced, special machine for making up to 18 in. x 24 in. positive enlargements of microfilm. Cost of this and similar-duty high-speed, continuous copying machines that will also copy bound book pages is high—range: $10,000 to $55,000. Under development is one to enable remote material to be copied by closed-circuit tv setup.

From: SAE Paper

TEN COMMANDMENTS FOR DESIGN

Mechanical simplicity, avoidance of redundant parts, liberal performance margins, adequate checking and inspection, etc. make up a 10-point checklist for product engineers.

B. BRADFORD RICHARDSON
Design Specialist
Fluid Systems, Norair Div,
Northrop Corp

Of vital importance in aircraft and missiles, design reliability is also an ever-present aim in all product design. These "Ten Commandments" should be referred to from time to time during all phases of design—and even during the maintenance period.

1. Provide for absolute mechanical simplicity.
Every element of the system which is not "absolutely reliable," should be challenged in an effort to: Eliminate it, simplify it or otherwise improve its reliability. The components that cannot be eliminated should be studied in every detail for simplicity and maximum reliability. As a rule of thumb, absolute reliability may be taken to be an average of less than one failure in 10,000 parts—even if the part will be called upon to operate only once in service.

2. There shall be no component in the system which by any stretch of the imagination or ingenuity can be avoided.
A relentless challenge of each component must be to make sure that it cannot be eliminated by an acceptable change in system configurations or an acceptable change in specified functional requirements or design conditions. Repeatedly challenge each component throughout the program to see if a situation change or an inventive thought can make it possible to remove it. When requirements are added to the system, and it must perform this way and that, then take this golden opportunity for re-examination, rearrangement, elimination, etc., don't let it just grow. The only sure way to make a functional piece of equipment absolutely reliable is to remove it from the system.

3. Simple mechanisms are more reliable than complex ones.
The ultimate is no moving parts. Challenge every moving part and every separate part to prove that it cannot be eliminated, simplified, or improved. As the saying goes, "If it moves kill it." Avoid delicate hardware. Avoid flow passages small enough to clog with contaminants which may sometimes be present. Close clearance sliding fits are generally to be avoided. Guides of all types, lengths, sizes and shapes, must be carefully designed and tested when used in a component. Materials, lubrication, storage life etc., must be studied in detail.

4. Functional equipment which is already in quantity production is more reliable than equipment developed and built especially for the system.
This is proving true especially for missile ground-support equipment where costs have been cut considerably. Why use them? Because they have been proven, the bugs have been worked out and they have been tested, both in the laboratory and in service. Recently the armed services, were requested to make a study to see if they could find a new method of proving reliability without the increased costs of additional life testing. They reported they could find no new method. An efficient packaging of components, of which there is a trend today will result in a possible elimination of moving parts and surely less plumbing or wiring, thus eliminating potential points of leakage or power losses.

5. The system shall be designed to have liberal performance margins rather than to be just adequate.
The performance margins shall be judiciously distributed among related functions to avoid a relatively weak link. The system analysis shall show the distribution of margin among related functions. For example: Design vital springs for 20% of normal design stress for the material. Also avoid difficult-to-accomplish physical functions, such as low-volume leakage.

6. The equipment design specification shall specify the type of system the part is to be used for, and that reliability is the major design requirement.
It shall establish detail requirements to project our reliability philosophy into the design of the component. The liberal performance margins provided by the system design shall not be wasted by allowing loose performance require-

RELIABILITY

ments in the equipment design specifications—in other words, allow no weak links in an otherwise strong chain.

Under "notes," in the detail component specification, the following should be included, "after successfully passing all qualification tests, approval of a submitted part constitutes authority for the vendor to proceed with the manufacture of additional duplicate parts. If any deviations or substitutions of design, methods, materials or dimensions are made after approval, immediate notification and/or written consent of the Engineering Department shall be required."

7. The system shall provide for checking every vital function of every component by the System Inspection Test after assembly is complete.
It must be possible to inspect every locking device as installed. Design so that physical interference prevents misassembly or misinstallation which is not readily obvious.

8. Provide for absolute minimum vital-complex functions.
By "vital functions" is meant functions which must take place in order for the mission to be completed. By "complex functions" is meant operations of complex mechanisms such as: Electrically actuated valves that require signals, external electrical circuits, and electrical reactions such as mechanical mechanisms that involve more than a few maximum-reliability parts working together.

9. Provide for absolute minimum vital human functions.
By "vital human functions" is meant function which must be performed by either aircraft and missile flight or ground personnel, which requires any degree of human judgment or memory, and which must be accomplished properly to complete the mission. "Absolute minimum" in this case not only means the fewest number but also the simplest, least likely to be done improperly, functions. The need for this objective is based on the relatively high probability that any human function, no matter how simple on paper, will sometime or other be done wrong or omitted.

10. Levels of reliability which have been accepted as inevitable for manned equipment are generally inadequate for automatic or remotely controlled equipment.
A new set of relative values must be developed, wherein reliability stands higher with respect to design time, component cost, weight, fabrication ease, and testing cost.

Application

To apply these "commandments" to a problem you will have not only to understand the specific requirements and operating conditions but also a depth of understanding surrounding the problem. Reaching the design absolutes is somewhat the same as working through an extremely intricate maze through which there may or may not be a passage. The only way to get through is to try every turn. The depth of understanding is necessary to recognize every possible turn.

Another aspect of understanding is to know the full scope of the problem. For example: Recognizing from the outset that provisions for testing and handling are part of the basic system problem rather than requirements to be tacked on by compromise after a system which will work well has been worked out. This, of course, applies especially to aircraft and missiles.

FUNDAMENTAL PROBLEM

Another important concept is to keep objectives for improvement in mind throughout the project. This emphasizes the fact that systems generally are not as static and committed at an early stage as they may appear. It often pays to have in mind at all times every feature of the system that it is desirable to eliminate or change and the current reasons which are preventing the improvement. As circumstances change with time, an opportunity may arise that will make incorporation of the improvement feasible if the designer is ready to move.

There is one fundamental problem, which always comes up in deciding what refinements in detail design are worth doing for the sake of reliability. The problem is fundamental because when you are trying to improve an already good design, you are evaluating chances in the range of 1 in 500 to 1 in 10,000 and the human mind is not capable of differentiating such orders of magnitude.

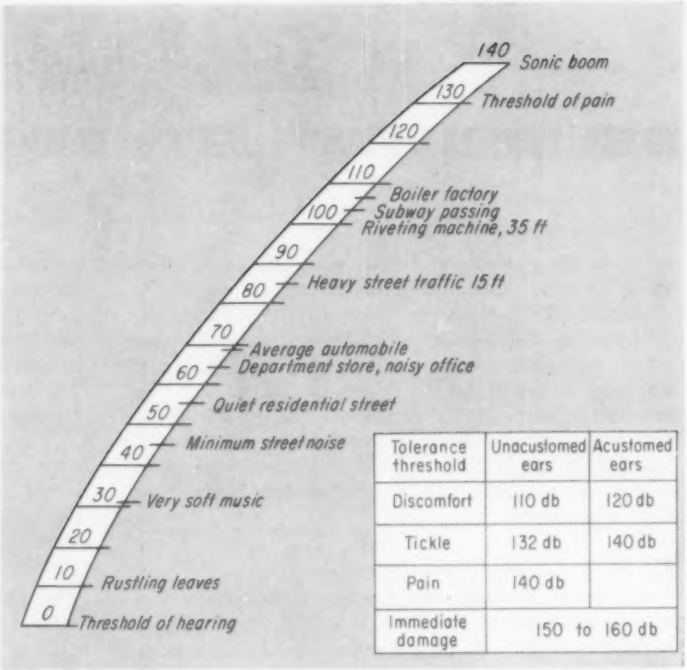
The policy which should be applied to meet this situation is to determine whether the change under consideration is plus or minus in terms of reliability. And then if it be plus, no matter how insignificant in appearance, make the change unless the costs are obviously out of line.

A persistent attack toward simplicity provides a bonus in addition to reliability—almost invariably a simple, reliable device is less costly to buy and maintain. The overall result of this approach generally is economy in dollars and the advantages of reliability are free. Never forget, however, that every step toward greater simplicity of design represents a great deal of engineering time and ingenuity.

REFERENCE:

Design for Reliability by B. Bradford Richardson, Design Specialist, Fluid Systems, Norair Div, Northrop Corp. Presented at SAE National Aeronautic Meeting, Los Angeles, California. Paper No. 101U.

From: Conference Paper



Tolerance threshold	Unacustomed ears	Acustomed ears
Discomfort	110 db	120 db
Tickle	132 db	140 db
Pain	140 db	
Immediate damage	150 to 160 db	

SOUND LEVELS of various environments in decibels. A "feel" for quantitative sound pressure levels is important in assessing subjective reaction to noise. The tolerance thresholds are upper limits; actually persons become annoyed with sounds of a much lower level than the extremes shown.

Noise reduction is important in product engineering at both the design stage and the operation of the finished product. Here is a brief rundown on . . .

NOISY

MYRON M. KAWA, JR.
Helicopter Project Engineer
Bell Helicopter Corp.
Ft. Worth, Texas

Noise, by definition, is an unwanted, objectionable sound that may interfere with speech communication on the job, or in leisure activities. Noise control is, therefore, a matter of considerable importance in products that operate at high sound levels. Not only is individual sales resistance to a noisy product involved, but community relations and employee efficiency must also be considered.

The most common method of sound level measurement is of over-all sound pressure level measured in decibles. This is a convenient way of obtaining relative comparisons especially for objects in motion.

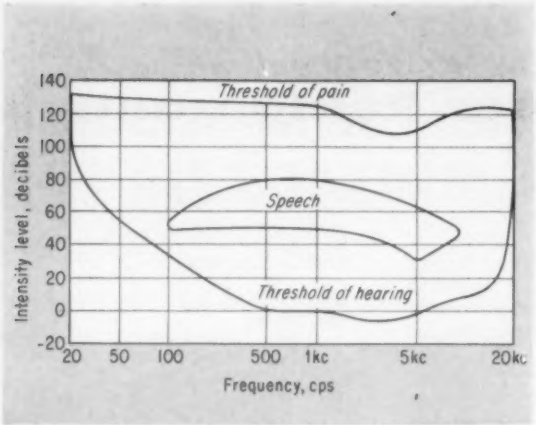
PROPERTIES OF NOISE

The amount of sound that can be tolerated by the average person is dependent upon several factors. First among these are: Over-all noise level; frequency spectrum; duration; acoustical absorption or reflection; distance from the source of sound; and ambient sound level of the area under observation. Combinations of the individual properties of sound need to be studied before something can be labeled objectionable or noisy.

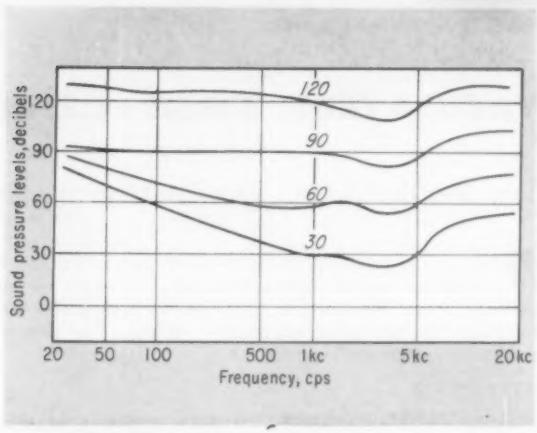
An average size truck starting up from a traffic light, for example, averages approximately 90 db in over-all noise level without attracting much attention from a person standing at a busy street intersection. However, an emergency vehicle with its siren operating and generating the same sound energy (90 db) at the listener, can be several blocks away and still demand a pedestrian's attention. It was designed to do so. The higher frequency, in cycles per second, is the attracting factor.

This is just one of the everyday experiences that indicate that over-all noise levels in themselves are not sufficient as an indication of the annoying effect of noise. The frequency distribution of the noise is important in this regard for people are less disturbed by low frequency than by high frequency noise.

Duration of a sound is a factor that can have a disturbing effect on people. Passing vehicles, such as cars, trucks, trains, or buses, can increase the noise level for a short period of time without having any marked effect upon the observer. If the sound is prolonged at the higher level, however, it may become irritating. The passing of a long freight train is an example of how the length of sound duration adversely affects a person.

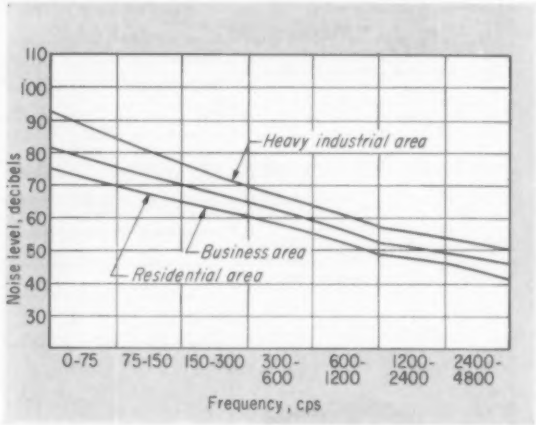


FREQUENCY AND INTENSITY ranges plotted in terms of speech levels and other thresholds show how intensity and freqeuncy must both be taken into account when assessing human reaction to noise.



EQUAL LOUDNESS curves where sound intensity varies with frequency. A sound with an intensity of 80 db at 20 cps has the same loudness as another sound with an intensity of 30 db at 1000 cps.

MAXIMUM PERMITTED SOUND levels as fixed by certain municipal governments for district zoning ordinances.



SOUND

The uncertain location of a noise may provoke in human beings, feelings of curiosity and even of insecurity which may interfere with other occupations and prove annoying. Example: the motorist who while driving his still relatively new car discovers a rattle. Although the noise level of the rattle itself is generally low, it can be disconcerting. An example: the novelty of the "blade slap" and "swish" of a helicopter. Although the actual sound level at only a few hundred feet might be as low as 80 db it attracts attention. Once the novelty has worn off the noise would no longer attract attention.

Another feature of noise which is very commonly found to be relative to its annoyance is the degree of variability in the noise itself. A sound which is modulated in intensity or frequency is sometimes found to be much more annoying than steady sounds. There is also some evidence that persons do not become accustomed to such noise as quickly as they do to steady ones. Example: aircraft noise in residential areas, where aircraft pass over only periodically. This occasional exposure can be more annoying than a continuous exposure to noise of the same level. There is strong evidence that complaints of aircraft noise are less frequent in neighborhoods that have a high permanent noise level.

The annoyance produced by a sound can be balanced by compensating advantages. Conversely, it seems that a sound which has no good reason for its existence is likely to produce severe complaints. A recent survey conducted in England showed that of those who notice the sound of delivery trucks in their homes, only 10% are troubled by the noise; of those who hear noises made by neighbors' pets, nearly 40% are troubled.

It is extremely difficult to place a quantitative value on the point where a sound becomes a noise. Persons react in various ways to noise stimuli, therefore, an evaluation of noise becomes strictly a statistical analysis of human response to noise.

REFERENCE:

Psychology of Sound and the Helicopter by Myron M. Kawa, Jr, Helicopter Project Engineer, Bell Helicopter Corp, Ft Worth, Texas. Presented at The Conference on Planning and Designing of Urban Helicopter Facilities, Sept 21 '59, Los Angeles, California.

From: Environmental Quarterly

TABULATED: Test-chamber Refrigerants

Dry ice, liquid CO_2, liquid nitrogen; and mechanical refrigeration compared.

Solid and liquid-state gases are expendable when used to cool test chambers. Mechanical refrigeration requires a permanent set-up. One of the main advantages of expendable materials is that temporary test structures are easily made—large test objects may be too big for the mechanical test-chamber available. The table compares expendable and mechanical refrigerant methods.

DALE J MISSIMER
Vice President
Missimers Incorporated
Glendale, Cal.

REFERENCE:

Expendable vs Mechanical—A Comparison by Dale J. Missimer, Vice President, Missimers Incorporated. Published in Environmental Quarterly, Oct 1959, p 17.

	Dry Ice (Expendable)	Liquid CO_2 (300 PSIG — 0° F) (Expendable)	Liquid Nitrogen (Expendable)	Mechanical Refrigeration
ADVANTAGES	Lowest cost expendable coolant Easily used for achieving −90 ° F quickly Direct application gives inert atmosphere Low capital investment Low service and maintenance costs Little power and no water or other utilities Fairly easy to control if used with secondary refrigerant Wide temperature ranges are possible—not limited to upper temperature of 400° to 500° F as is mechanical refrigerant	Low capital cost Easily controlled for temperature and capacity No storage losses Little power required for operation, no water or other utilities Low handling costs Direct injection gives inert atmosphere Low maintenance and service costs Easy to achieve −90° F quickly No limitations of upper temperatures for chamber Quickly takes up large cooling load increases	Easily used for direct or indirect cooling system, with N_2 or air atmosphere Easily used at one atmospheric pressure for liquid- vapor-phase refrigeration—no solid phase problems Chamber free of frost and snow inside when direct injection used Easily produces temperatures to −300° F Temperature and capacity from room ambient to −300° F easily controlled Atmosphere can be inert if desired No limitations for upper temperature of chamber Low capital cost Low power requirements Low maintenance costs Can easily take up large load increases Non-toxic	Low operating costs Low handling costs Easily controlled for both temperature and capacity Only electrical power required for air cooled systems Not dependent upon supply of materials which are not always convenient to obtain No storage losses Can produce lower temperatures than CO_2 No ventilation required for expended vapors Atmosphere is air Easily used for altitude test chambers without necessity of secondary refrigerant Suitable for humidity control systems Usually most economical down to −40° F depending on usage Good heat transfer characteristics Not hazardous to operating personnel
DISADVANTAGES	Relatively high handling costs More difficult to control temperature than liquid expendable refrigerants, for direct application Direct application results in snow in chamber, and atmosphere is not air Must have ventilation or provide for exhausting CO_2 vapors Higher losses in storage Difficult to control capacity automatically with changes in loads, even with indirect system Lowest practical temperature is −90° to −100° F Relatively poor heat transfer characteristics Not very economical down to −30° or −40° F Slightly toxic Capital investment higher if used with secondary refrigerant	Relatively high operating costs For direct injection, snow may be objectionable Atmosphere not air Ventilation required for larger flow rates Expansion devices subject to plugging For direct injection, sublimation takes place at only one low temperature (approx −109.4° F), making control at moderate temperatures more difficult Requires storage receiver floor space Not particularly economical down to −30° to 40° F Lowest practical temperature is −90° to −100° F Triple point of −69.9° F presents major problem because can't be used as liquid-vapor-phase refrigerant at near atmospheric pressure Slightly toxic	Storage and/or availability can present problems Relatively high operating cost, unless there is large monthly usage Hazardous if spilled on human beings Ventilation may be required when large amounts are used Generally not economical for cooling at temperatures above −100° F Heat transfer at high temperature-differentials is poor Control methods or devices slightly more complex and expensive than for liquid CO_2 Storage costs generally higher than for liquid CO_2 or dry ice	Higher capital costs More floor space required Higher maintenance costs More skilled personnel required for service Slower cooling rates, generally Water for cooling generally required for larger systems Practical upper temperature limit of 400° to 500° F for chamber without special temperature isolation provisions "Inerting" requires separate source of vapor More electrical power required Not economical for infrequent low temperature tests of short duration Defrosting of heat exchanger surface can be a problem

From: Company Handbook

basic information on . . . AIR FILTRATION

Data on particle sizes of airborne contaminants, types of filtration equipment, and 5 standard test-methods.

Air filtration is necessary for protecting small, precision equipment as well as for such industrial applications as recovering dust caused by buffing and polishing gold and platinum jewelry; preventing escape of radioactive and other materials hazardous to life; keeping sterile air clean for antibiotic drug manufacture.

The design engineer called upon to choose a filtering system is confronted with a subject about which there exists much confusion. Unfortunately, the purchase and installation of equipment of unsuitable character can be costly as it may not produce the sought-for results and will most certainly be more expensive to maintain. In extreme cases, the entire installation may have to be replaced with loss of the original investment. For this reason, basic information on air cleaning in general and air filtration in particular is important. A proper choice of air-cleaning equipment depends largely on these three factors: The character and amount of dust and dirt in the air to be cleaned; percentage removal desired, or economically feasible; and service life or servicing cycle of the equipment. These factors apply equally for ventilation, process- and exhaust-air cleaning.

When the requirements for clean air are exacting, all factors should be evaluated carefully and air sampling may be advisable to measure particle size and dust loading. This is particularly important when completely dust-free process-air is required or when exhaust air contains dust of an injurious nature.

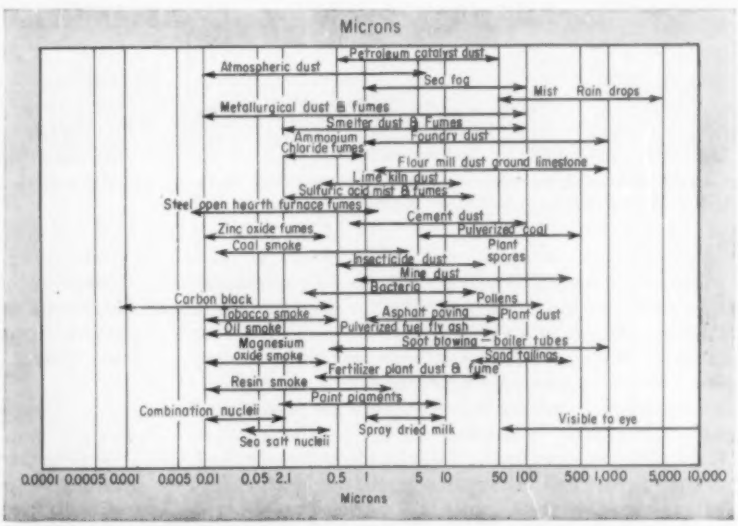
TYPES OF CONTAMINANTS

Particle sizes of common airborne contaminants are shown in Fig. 1. The preparation of dust-free process-air is made difficult at times because the sources of contamination can be two-fold: Dust produced by the process itself, and dust normally present in the atmosphere. Atmospheric dust varies greatly in size. Fig. 2 illustrates dust loadings characteristic of many industries. At times, two different filtration systems may be necessary; one to clean up air contaminated by the process and another to remove atmospheric dust.

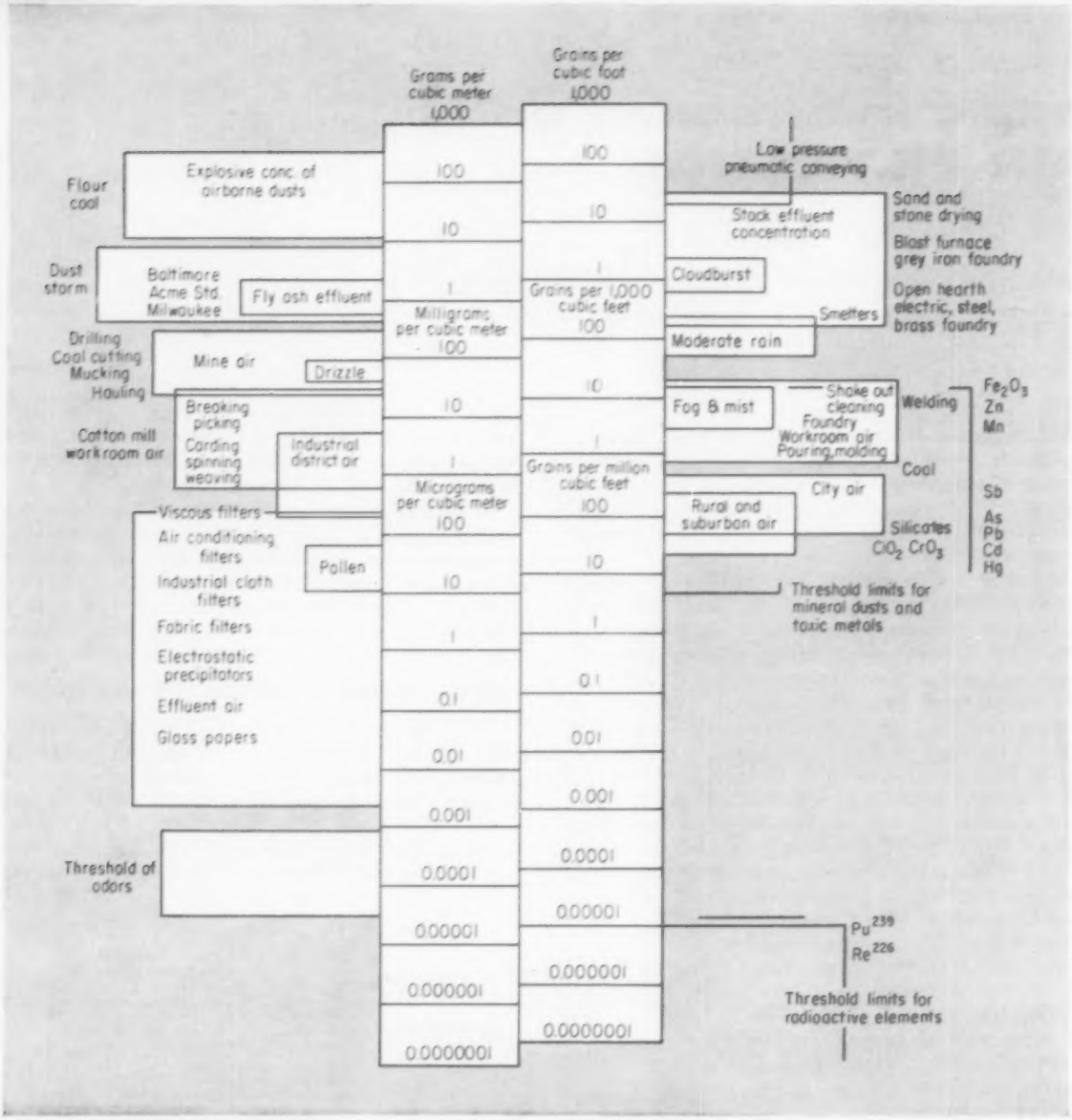
In office buildings it may be assumed that the recirculated air contains approximately the same contaminants as the intake air. In hospitals and many types of laboratories, however, bacteria or dangerous chemicals may enter the room air during normal activities and these must be removed prior to recirculation, if recirculation, with its savings in winter and summer, is to become possible.

DETERMINATION OF PARTICLE SIZE AND WEIGHT

The weight of dust in an air or gas stream can be determined in a number of ways. Usually the most satisfactory method is to draw a measured volume of air or gas through a sampling filter capable of retaining all the dust. Total volume sampled may range from a few cubic feet to many hundreds of cubic feet of air depending upon dust loading and sensitivity of the analytical technique.



1.—SIZES OF AIRBORNE CONTAMINANTS. It would take 112,007,483 particles, 0.3 microns dia, to cover an ⅛-in.-dia area.



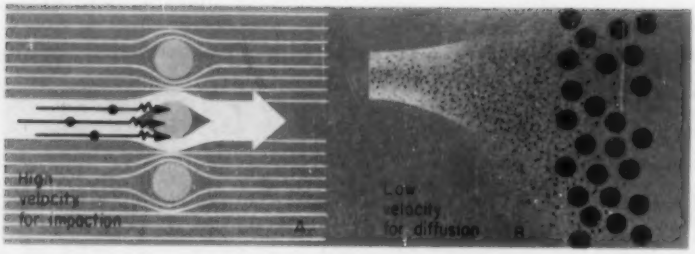
2.—DUST LOADINGS for industries and climatic conditions. Both this and Fig. 1 serve as a guide to the type of equipment needed for air cleaning.

When dust loadings are large, samples for particle size determination may be scraped off the deposited dust cake from filters used for weight determination. The dust is redispersed in air, water or oil, and particle size determined by: (1) microscopic measurement of several hundred particles (2) settling velocity under the influence of gravity (3) particle settling-velocity by centrifugation or (4) decanting in air or water. Direct particle measurement by light or electron microscope is the preferred sizing method when particles are small and dust loadings are low. Particles may be sampled with special transparent-membrane filters and examined directly under the microscope.

Much additional information on filtering characteristics which bears on filter service life may be obtained by noting the rate of pressure rise and weight increase of the sampling filters.

TYPES OF FILTRATION EQUIPMENT

No single type of air cleaning equipment is capable of handling all problems efficiently. For best results, it is frequently necessary to use two or more air cleaners in series. Certain types of dust removal equipment which are excellent for removal of heavy loadings of coarse dust



3.—IMPACTION AND DIFFUSION methods trap dust by utilizing the fact that particles (A) resist change of direction because of their inertia, and continue in their original path, or (B) extremely small particles behave as true gases and diffuse throughout the filter always tending to achieve uniform distribution.

TABLE I—Dust-collector Selection

Grains per cu. ft. of air	Particle Size		
	0.1-1.0 Microns	1-10 Microns	10-100 Microns
0.0001 to 0.001	Absolute filters	Deep beds of small-dia fibers	Deep beds of large-dia fibers
0.001 to 0.01	Deep beds of small-dia fibers Low-voltage 2-stage electrostatic precipitator	Deep beds of small-dia fibers Low-voltage 2-stage electrostatic precipitator	Wet fiber washer Deep beds of large-dia fibers
0.01 to 0.1	Disintegrator High-voltage electrostatic precipitator	High-voltage electrostatic precipitator	Wet fiber washer Spray washer
0.1 to 1.0	Disintegrator High-voltage electrostatic precipitator Industrial-cloth collector	Industrial-cloth collector	Wet fiber washer Spray washer
1.0 to 10	Industrial-cloth collector High-voltage electrostatic precipitator	Industrial-cloth collector Mechanical centrifugal collector Small-dia multicyclone	Small-dia multicyclones Spray washer Large-dia cyclone Inertial baffle-chamber Gravity-settling chamber

are ineffective for finer particles. For example, dirt appearing around air-supply grills and diffusers is an indication of incomplete air cleaning. On the other hand, many filters capable of removing fine particulate material must be preceded by less efficient filters to remove the bulk of coarse dust in order to extend the service life of the final, more efficient, unit.

Table I indicates the effective particle size and dust loading range of many commonly-used dust collectors. The categories are by no means rigid, since dust-collector selection is based on consideration of service life, reliability and maintenance costs as well as on the factors indicated.

CLASSIFICATION OF AIR FILTERS

Air filters can be divided into three groups:

INDUSTRIAL FILTERS handle high dust loadings at low air flow rates and are usually equipped with self-cleaning mechanisms. Woven fabrics of natural and synthetic fibers and wool felt are the most common filter materials. Dust or fume loadings may be as high as 10 grains of solids per cubic foot of air.

VENTILATION FILTERS handle low dust loadings at high velocities. These may be self-cleaning units of any size or panels of approximately 24 in. x 24 in. face area and 2 to 6 in. depth of the "throw-away" or manually cleanable type. Filtration velocities of 400 to 500 fpm are not uncommon. Filter media include porous beds of mineral or vegetable fibers, crimped wire mesh or twisted metal tapes. Dust catching elements are usually coated with a sticky oil to prevent loss of collected dust and fibers. These filters are effective for the coarsest fraction of air-borne dust and lint and seldom remove more than 10 to 20% of atmospheric dust except in areas of concentrated heavy industry.

HIGH EFFICIENCY FILTERS handle low dust loadings at low filtration rates and certain types are valued for their ability to remove the very smallest dust particles from air and gas streams at high efficiency. Filter papers of various compositions are in widespread use for these especially exacting filtration requirements. Woven fabrics or felt filter cloths are occasionally substituted for paper because the cloth surfaces may be vacuum-cleaned and returned to service, but filters in this category are generally discarded and replaced when their service life is exhausted. High efficiency filters have found extensive application for removal of toxic agents from stack dischargers and for supply of dust-free and bacteria-free air to critical production or laboratory areas. Because of the extremely high dust retention characteristics of certain of these filter papers composed of glass, ceramic or cellulose-asbestos fibers, they have been characterized as "absolute" filters. Filtration velocities range from 5 fpm upward but seldom exceed 20 fpm. High airflow capacity is achieved by extensive pleating of filter medium.

FILTRATION THEORY

An air stream is broken up into many smaller streams as it traverses the narrow, tortuous passages within a porous filter bed and entrained dust particles are brought into close proximity to the filter elements. Filtration takes place when a dust particle in the air contacts a filter fiber and sticks to it. All filters remove particles very much smaller than the smallest pores or openings so that removal of particles by "straining" is not a major consideration.

If particles were removed by straining, all pores would soon become completely clogged by one or more particles and airflow would cease. Instead, particle deposition takes place throughout the depth of the filter and, ideally, a dense, high resistance dust layer does not build up on the filter surface.

Deposition of particles on filter fibers occurs in several ways. It is believed that electrostatic attraction between

TABLE II—Comparison of Test Methods for Determining Filter Efficiency

Test Method	Test Dust	Method of evaluating inlet dust loading	Method of evaluating outlet dust loading	Method of evaluating filter effic'y.	Class of filters for which test method is most applicable
ASHVE	Synthetic dust composed of 50% lamp black and 50% ash from Pocahontas coal passing 200 mesh sieve	Pre-weighed charge of dust fed to test filter	Air is sampled and weight increase of sample filter measured	Percent retention by weight	Viscous-coated impingement-type ventilation air filters
NBS (a)	Atmospheric dust	Staining or discoloration of a white filter paper	Same as inlet	Percent reduction in discoloration properties	Electrostatic precipitators and fibrous air filters capable of effecting substantial reduction in staining properties of ventilation air
NBS (b)	Synthetic dust composed of 96% Cottrell precipitated pulverized coal fly ash and 4% lamp black. Cotton linters may be introduced from a separate feed nozzle	Same as when using atmospheric dust	Same as when using atmospheric dust	Same as when using atmospheric dust	Same as for ASHVE test method. In addition may be used as an accelerated test of air cleaners for which atmospheric dust is a suitable test dust
Fractional Efficiency Method	Arizona Standard Road Dust—fine, separated into 5 fractions containing particles between 0–5, 5–10, 10–20, 20–40, and 40–80 microns	Air is sampled and weight increase of sample filter measured	Same as inlet dust loading	Percent retention by weight for each size fraction	Same as for ASHVE test method. Smallest size fraction may have application to tests on filters capable of removing staining fraction of atmospheric dust
AFI	Synthetic dust composed of 72% Arizona Standard Road Dust—fine, 25% K-1 carbon black, 3% No. 7 cotton linters	Same as for ASHVE test	All of cleaned air passed through a pre-weighed filter capable of retaining dust penetrating filter undergoing test	Percent retention by weight	Same as for ASHVE test method
DOP	Droplets of dioctyl-phthalate; uniformly 0.3 micron in size	Electronic measurement of amount of light scattered by DOP	Same as inlet loading	Percent by number of droplets penetrating filter	Absolute-type filters and those possessing similar filtration characteristics

particle and filter may be of importance in some cases.

Direct interception also plays a part in filtration; in effect, a particle literally bumps into a fiber directly in its path. This filtration action, like straining and electrostatic charge, it is believed to be of minor importance in the majority of cases and most dust separation takes place by *impaction* and by *diffusion* (Fig. 3).

Calculations indicate a particle diameter of 0.3 microns as likely to be the most difficult to filter and this size smoke particle has been selected by the Army Chemical Center as the standard test material for their service gas-mask (DOP test).

Small diameter fibers are usually associated with high filtration resistance so that filtration efficiency is correlated roughly with filter resistance. Thus, ventilation filters, composed of large diameter fibers, operate at airflow resistances less than 0.25 in. of water (in spite of filtration velocities of 400 to 500 fpm), while highest efficiency filters have initial resistance approaching 1.0 in. of water at airflow velocities no greater than 6 fpm.

RATING FILTER PERFORMANCE

Dust Arrestance–Contrary to popular belief, all air filters except those specifically designed to trap only the coarsest of airborne particles increase in collection efficiency with use and are at the peak of their dust arrestance when they are ready for cleaning or replacement. Therefore, it is necessary to distinguish between initial (clean filter) efficiency and "average" efficiency over the entire life of the filter. The latter value reflects the natural increase in arrestance which occurs while the filter ages and for some filters the average efficiency will be considerably higher than initial efficiency. Filter efficiency is usually expressed as the percentage of dust reaching the filter that is retained.

Airflow Resistance–Filter resistance is the force opposing airflow and is expressed in terms of the height of a column of water exerting an equivalent pressure. This convention arises from the universal practice of measuring filter resistance with the aid of a liquid-filled U-tube manometer by noting the linear displacement of the liquid level in the two legs. Filter resistance is of importance as it is a direct measure of the power required to draw air through it and accurately reflects one item of filter operating cost.

Service Life–Filters must be replaced or renewed when their resistance increase exceeds the capabilities of the system air blower. Service life of identical filters will vary according to the quantity and nature of the collected dust as well as the volume-static pressure characteristics of the air blower. If the dust loading to the filter doubles, service life will decrease by one half, all other factors remaining the same. Large particles generally cause less filter resistance than an equal weight of smaller particles deposited on or in the filter.

FILTER TESTING

In 1951 at least one filter manufacturer proposed a modified American Society of Heating and Ventilating Engineers (ASHVE) test in which a series of test dusts of narrow particle size range are used for filter evaluation. Another group of approximately a dozen filter manufacturers, acting together as the American Filter Institute (AFI) proposed a different modification of the ASHVE test and have submitted it to the U. S. Dept. of Commerce for acceptance as a voluntary trade standard.

During World War II the Army Chemical Corps engaged in extensive research and development activities directed toward improving smoke filters for use in service gas masks. Since gas-mask filters must possess filtration efficiencies far greater than those required of supply air cleaners, the ASHVE and NBS tests were totally inadequate as they lacked the ability to discriminate between smoke filters of varying capability. Therefore, the Chemical Corps adopted the DOP test which is based on the use of a dioctylphthalate test smoke of extremely small size, and optical evaluation of the smoke fraction penetrating the filter. Many other test methods and test aerosols have been used for experimental studies of filter performance but most commercial filters are rated by one or more of the above test methods.

1. ASHVE Test

For this test a filter is operated at its rated airflow capacity and a known weight of a prepared dust is injected into the air supply to the filter.

The principal objections to the ASHVE test are:

1. Since the test dust dispersal mechanism does not break up the lamp black fraction into unitary particles and the coal ash contains many large particles in any case, even the poorest air filters receive high dust retention ratings by this test.

2. The test dust is not adequately specified so that users may be assured of starting with the same particle size content. In addition, the dust dispersal mechanism has not been sufficiently well defined. Consequently, it has been difficult to duplicate test results in other laboratories.

3. Dust is injected at a single point upstream of the filter and good dust distribution across the entire face of the filter is not always obtained.

4. Poor dust distribution can exist ahead of the test filter, considerable difficulty may be experienced in obtaining a truly representative sample on the clear air side of the test filter.

2. NBS Discoloration Test

The purpose of this test is to measure the reduction in soiling properties of ventilation air on the assumption that this is one of the major objectives of supply air cleaning. Samples of cleaned and uncleaned air are drawn through white paper filters simultaneously and the sampling rate of the cleaned air adjusted until the two white sampling filters discolor at the same rate. Discoloration of the test filter papers is measured with a photocell.

The principal objection to the NBS discoloration test (using outdoor air as the test aerosol) is that atmospheric dust varies in size, loading and composition depending on location (rural, urban and industrial atmospheres), season and weather (dry, windy weather produces large quantities of coarse air borne dust whereas practically all dust disappears following a rain or snow storm).

3. Fractional-efficiency Test

This test follows the procedures of the ASHVE method quite closely except for the test dust. The test dust is composed of 50% Arizona road dust and 50% lamp black. The unknown filter is tested successively with each of the dust-fraction sizes and the test data plotted to yield a smooth curve showing filter efficiency (expressed as the % by wt. retained) for each particle size in the range 0-80 microns.

Procedure-wise, improvements to the ASHVE test include injecting the test dust at 4 points in the duct cross section (instead of a single dust feed point) and an improved dust dispersion mechanism.

Objections have been raised that the dust separation techniques do not yield fractions sufficiently uniform in size to make the results obtained by this method very reliable.

4. AFI Test Code

The AFI test is closely similar to the ASHVE test procedure but seeks to improve it by specifying a standard test dust available from a commercial source. In addition, the dust dispersal mechanism and operational details are closely regulated so that although there is no assurance that the bulk powders are completely dispersed, it is claimed that there is at least good reproducibility of the size characteristics of the aerosol that is produced.

5. DOP Test

As practiced by the Army Chemical Corps, a homogeneous dioctylphthalate fog is generated by mixing air containing DOP vapor at 170°C and clean air at 25°C in a volume ratio of 1:4. The concentration is adjusted to about 40 grains per thousand cubic feet and particle size to about 0.3 microns. Space filters are usually tested at 5 fpm and air sampling filters at 28 fpm air velocity. Particle size and smoke concentrations upstream and downstream of the test filter are determined to a very high degree of accuracy by optical methods utilizing a relative amount of light scattered by the smoke particles. The DOP test is reserved for evaluating the most efficient filters (often called absolute filters) and others of somewhat lesser capabilities.

All the test methods yield comparative results only, which may or may not be an accurate reflection of results obtainable in practice. The tests are useful as an index of performance and can be valuable for comparing one filter with another under identical conditions. The wide range of air contaminants encountered in practice and the varied requirements of users make the application of a single universal filter test impractical. However, among the several tests that are available, it is usually possible to select one which most closely duplicates the conditions under which the filter must operate.

REFERENCE:

Filtration Handbook, published by Flanders Filters Inc, Riverhead, N. Y.

GENERAL ENGINEERING

From: Plastics

WHEN PLASTICS BURN . . .

. . . What are the hazards from toxic fumes? . . .

Reviewed are published results of work on this problem. Analyses of decomposition products of 18 materials are also presented.

E. H. COLEMAN, *Senior Experimental Officer, Department of Scientific and Industrial Research England*

Fears are frequently expressed that synthetic resins and plastic materials involved in fires will yield combustion products that are more toxic than those usually occurring in fires involving materials such as wood or traditional textiles.

It was claimed, although later disproved, that hydrogen cyanide would be a major hazard if melamine resins were involved in fires. Particular concern has been felt, however, about materials that contain halogens, generally chlorine, which when pyrolyzed can yield free halogen, hydrogen halide, and possibly carbonyl halides analogous to phosgene and it has been considered that these gases would be present in sufficient concentrations to constitute the major toxic hazard. Results from many sources of investigations of various combustion products are summarized in Table I.

The combustion products are generally well-known gases that have been studied by toxicologists. Unfortunately, however, there are gaps in the knowledge of both the effects of combined gases, and of brief exposures to high concentrations.

Table II gives a summary of the effects of some gases commonly encountered in fires. Since oxygen deficiency also occurs, the effects of this condition have been included. Table III.

COMBUSTION PRODUCTS

It is necessary to distinguish between "pyrolysis products" such as would be produced by heat in the absence of air, and the "combustion products" which would appear if the materials were involved in a fire with a copious supply of oxygen. Thus the pyrolysis products of cellulosic materials include water vapor, tars, tarry acids and flammable gases, whereas the combustion products will be principally water vapor carbon dioxide and carbon monoxide.

This review is concerned with combustion products since it is the latter which are more likely to be encountered in fires.

BASIC FACTS

From all the tests done certain facts are evident. Since fires usually involve cellulosic or other carbonaceous material, carbon dioxide and carbon monoxide will always be present, and at some stage there will be a deficiency of oxygen. The toxic gases that could be present will depend upon the material involved, thus nitrogenous materials such as wool, silk and certain resins may evolve hydrogen cyanide and ammonia; nitrous fumes may be present if celluloid is involved and chlorinated plastics will produce hydrogen chloride, but it is very doubtful if carbonyl chloride would be present in hazardous concentration.

Fluorine compounds such as Teflon would be expected to behave similarly to chlorinated plastics but the compounds have a greater stability, and therefore, in addition to hydrofluoric acid, there could be present also gaseous fluorocarbon compounds. This would be most likely to occur with the lower temperature conditions early in the fire.

The proportions of the gases will vary with the prevailing conditions. In dwellings the combustibles will be mainly cellulosic and the major hazards will be carbon monoxide and oxygen deficiency. In this connection the effects of a combination of conditions such as carbon monoxide with carbon dioxide, or may be with oxygen deficiency, could well be worse than being purely additive. With industrial premises where plastics are produced and fabricated, large storages may exist and in these instances gases other than carbon monoxide may become significant, although products such as hydrogen chloride and ammonia are exceedingly irritating at concentrations below the dangerous level and thus give a warning of their presence. Many plastics are incombustible, but they will be heated to destruction by the combustibles in the building, and the gases will then approximate to pyrolysis products, among which will be dense smoke. This exceedingly copious production of dense black smoke occurs in all fires involving chlorinated compounds such as polyvinyl chloride or chlorinated rubber plastics, and with fire-extinguishing agents or solvents such as carbon tetrachloride.

CONCLUSIONS

Generally, in the majority of fires, whether in dwellings or industrial premises, the principal toxic combustion product would be carbon monoxide, and although other more lethal gases might also be present the volume of carbon monoxide would be so much the greater that it would constitute the major hazard. Many of the gases evolved are irritants and this, combined with the copious smoke emission, which would be the position if large amounts of plastics were involved, would compel the use of self-

TABLE I—DECOMPOSITION PRODUCTS OF PLASTICS

Material	Method of Testing	Analyses (per cent volume)										Notes
		Oxygen O_2	Carbon Dioxide CO_2	Carbon Monoxide CO	Chlorine Cl_2	Hydrogen Chloride HCl	Carbonyl Chloride $COCl_2$	Hydrogen Cyanide HCN	Ammonia NH_3	Hydrogen Sulphide H_2S	Nitrous Fumes as NO_2	
Melamine resin paper, or wool	Heated in a current of air and products passed over rats in cages	Not analysed										Demonstration that shows toxicity was due to carbon monoxide and not hydrogen cyanide.
Wood	5 lb. burned in 110 cu. ft. air	9.8	6.2	6.2	—	—	—	—	—	—	—	
Rubber	Insulation on cable in flask	6.6–13.4	6.6–13.6	3.4–7.6	—	—	—	—	—	0.1	—	10% of hydrocarbons.
Wool	Heated in silica-tube with a current of air	6.6–14.2	4.6–9.2	0.5–5.0	—	—	—	1.3–2.5	1.3–2.6	0.02–0.40	—	
Silk		4.0–8.0	8.0–12.6	3.0–4.4	—	—	—	2.2–6.8	3.1–3.6	—	—	
Timber and fiber insulation board	Burning house	19.9	0.7	0.3	—	—	—	—	—	—	—	3 min. from start.
		1.6	17.8	19.8	—	—	—	—	—	—	—	1.9%hydrogen 12 min. from start
		0.3	9.2	16.7	—	—	—	—	—	—	—	47% hydrogen 18 min. from start.
Chlorinated methacrylate resin 27% chlorine	0.5 g at 550°C	nd.	2.6	2.2	0.0	0.6	0.0005	—	—	—	—	
Poyvinyl chloride 57% chlorine	0.25 g at 550°C	n.d.	2.1	1.1	0.0	1.8	0.0005	—	—	—	—	
Polyvinyl chloride fabric	0.5 g at 550°C	n.d.	2.0	0.4	n.d.	2.9	n.d.	—	—	—	—	
Plywood	Heated at 550°C	2.8	17.1	3.6	—	—	—	—	—	—	—	3.4%hydrocarbons.
Plywood P.V.C. and flame-retardant paint	Heated at 550°C	2.1	17.1	5.1	—	3.1	—	—	—	—	—	
Plywood with polyester resin and flame-retardant paint	Heated at 550°C	2.6	14.7	13.2	—	3.8	—	—	—	—	—	
P.V.C coating only	Heated at 550°C	0.3	10.1	5.8	—	4.7	—	—	—	—	—	
Vinylidene coating only	Heated at 550°C	17.0	0.4	—	—	1.1	—	—	—	—	—	
Foamed polyvinyl chloride	2–3 g heated electrically, in 270–1 air	20.7	0.16–0.35	0.023–0.040	0.0	0.005–0.023	0.0	0.001–0.003	0.002–0.003	—	0.001–0.002	Tests made to examine effects of blowing agents.
Foamed acrylonitrile		19.3	1.26–1.31	0.041	0.0	0.002	0.0	0.002	0.002	—	0.002	
Phenolic resin with fillers	As above	n.d.	n.d.	0.017–0.046	—	—	—	0–0.003	0.002–0.110	—	—	Carbon monoxide was highest with fillers such as wood meal and cotton.
Melamine resin with fillers		n.d.	n.d.	0.012–0.075	—	—	—	0.002–0.25	0.006–0.180	—	—	

TABLE II—THE PHYSIOLOGICAL EFFECTS OF GASES OCCURRING IN FIRES

Effect	Concentration (parts per million)								
	Carbon Monoxide CO	Chlorine Cl_2	Hydrogen Chloride HCl	Carbonyl Chloride $COCl_2$	Hydrogen Fluoride HF	Hydrogen Cyanide HCN	Ammonia NH_3	Hydrogen Sulphide H_2S	Nitrous Fumes as NO_2
Safe for several hours	100	0.35–1.0	10	1.0	1.5–3.0	20	100	20	10–40
Safe for 1 hour	400–500	4	50–100		10	50–60	100		
Dangerous ½ to 1 hour	1500–2000	40–60	1000–2000	25	50–250	100–240	2500–4500	200	100–150
Fatal in ½ hour	4000					200–450		600	
Rapidly fatal		1000	1300–2000	50		3000	5000–10000	1000	200–700
Least amount causing throat irritation		15	35	3.1			408	100	62
Least detectable odor		3.5		5.6			53	10*	

* Sense of smell lost after 2 to 15 minutes exposure to 100—150 p.p.pm.

TABLE III—THE EFFECTS OF OXYGEN DEFICIENCY

Effect	Oxygen per cent by volume O_2
Candle extinguished	17
Respiration affected	10–14
Nausea	6–10
Rapidly fatal	6

contained breathing apparatus. This would be especially the situation if the plastics were chlorinated compounds such as chlorinated rubber or polyvinyl chloride.

A hazard certainly exists when plastics are involved in fires, but apart from extra smoke the total hazard is the same that has always existed, and fear of the additional gases evolved must not obscure the realization of the hazards of carbon monoxide and oxygen deficiency.

ACKNOWLEDGMENTS

The work described in this article forms part of the program of the Joint Fire Research Organization of the Department of Scientific and Industrial Research and Fire Officers' Committee; the paper is published by permission of the Director of Fire Research. The author wishes to thank Dr. F. E. T. Kingman, who has made many suggestions and helpful criticisms.

REFERENCE:

Gaseous Combustion Products from Plastics by E. H. Coleman, Department of Scientific and Industrial Research and Fire Offices' Committee, Joint Fire Research Organization, England. Published in Plastics, October '59, p. 416.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(A-1) **Ground Support Equipment**—Brochure, 4 pp. Describes products for engine starting, fueling, flushing and other aircraft servicing. Airaterra, 620 Paula Ave, Glendale 1, Cal.

(A-2) **Aircraft Equipment**—Catalog, 25 pp. Describes mechanical, electromechanical and electronic gear such as actuators, inverters, controls system components and others. Airborne Accessories Corp, 1414 Chestnut Ave, Hillside 5, NJ.

(A-3) **Flexible Metal Hose and Tubing**—Catalog, 66 pp. Gives dimensions, weights, other engineering data for corrugated and stripwound types. Includes fittings, vibration eliminators. Anaconda Metal Hose Div, The American Brass Co, 698 S Main St, Waterbury 20, Conn.

(A-4) **Expansion Tubing Connector**—Bulletin, 4 pp. Provides dimensions, pressure ratings of tubing for making moving or out-of-line connections. Anaconda Metal Hose Div, The American Brass Co, 698 S Main St, Waterbury 20, Conn.

(A-5) **Clamshell Buckets**—Catalog, 28 pp. Gives sizes, capacities, construction of buckets for digging, dredging, rehandling, other purposes. Blaw-Knox Co, Box 1198, Pittsburgh 30.

(A-6) **Nameplates**—Brochure, 4 pp. Describes self-adhering polyester film made into trim, gage faces, kick plates. Tells how to specify. W H Brady Co, 727 W Glendale Ave, Milwaukee 9.

(A-7) **Locks**—Bulletin, 6 pp. Gives mechanical and electrical data on general and switch locks. Chicago Lock Co, 2050 N Racine Ave, Chicago 14.

(A-8) **Valves**—Brochure, 4 pp. Shows construction, dimensions and service recommendations for check, relief, shut-off and plug valves. Circle Seal Products Co, Inc, 2181 E Foothill Blvd, Pasadena, Cal.

(A-9) **Drafting Papers**—Brochure, 18 pp. Contains samples of tracing and drawing, graph, grid, fade-out grid and other papers for reproduction. Includes price lists. Clearprint Paper Co, 1482 67 St, Emeryville, Cal.

(A-10) **Radiant Heaters**—Catalog, 16 pp. Describes construction, dimensions, installation, operation and maintenance of glass tubular and panel type infrared heaters. Corning Glass Works, Corning, NY.

(A-11) **Plastic Knobs**—Catalog, 8 pp. Presents dimensions and specifications of variously shaped knobs, handles, handwheels from stock molds. Dimco-Gray Co, 207 E 6th St, Dayton 2, Ohio.

(A-12) **Vibration Mounts**—Brochure, 6 pp. Describes pad type machinery mounts. Unisorb Div, The Felters Co, 210 South St, Boston.

(A-13) **Whiteprinting Machines**—Catalog, 18 pp. Describes range of machines from desk to automatic 100 fpm models. Ozalid Div of General Aniline & Film Corp, Ansco Rd, Johnson City, NY.

(A-14) **Toolroom Components**—Catalog, 88 pp. Contains descriptions of clamps, cam handles, T-bolts, levers and similar accessories for the machine shop. Jergens Tool Specialty Co, 712 E 163 St, Cleveland.

(A-15) **Plastic Knobs**—Catalog, 15 pp. Provides illustrations and dimensions for thermosetting plastic knobs, dials and assemblies. Kurz-Kasch, Inc, 1421 S Broadway, Dayton, Ohio.

(A-16) **Reinforced Plastics**—Brochure, 8 pp. Describes types of glass reinforced polyester resin parts company will make. G B Lewis Co, 3426 Montgomery St, Watertown, Wisc.

(A-17) **Special Wrenches**—Data sheets, 5 pp. Gives an idea of special handles, drives, socket openings, materials that can be supplied. Details a few. Lowell Wrench Co, 97 Temple St, Worcester, Mass.

(A-18) **Blowers**—Bulletin, 6 pp. Lobe blowers have 50 to 4000 cfm capacities and pressures of: single stage, 14 psig; multistage, 70 psig. M-D Blowers, Inc, 100 Fourth St, Racine, Wisc.

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(A-20) **Seats**—Catalog, 18 pp. Illustrates and dimensions cushioned and contour seats for mobile equipment. Milsco Mfg Co, 2758 N 33 St, Milwaukee, Wisc.

(A-21) **Gear Pumps**—Bulletin, 15 pp. Gives dimensions, hp ratings, construction of pumps capable of handling ¼ to 146 gpm of a wide variety of liquids. Northern Ordnance, Inc, Columbia Hts P O, Minneapolis 21, Minn.

(A-22) **Blueprint Files**—Catalog, 12 pp. Describes vertical and roll print files, racks, cabinets, tables. Plan Hold Corp, 5204 Chakemco St, S Gate, Cal.

(A-23) **Axle Assemblies**—Brochure, 4 pp. Describes assembly which includes differential and power brakes. For large equipment. Rockwell-Standard Corp, Transmission & Axle Div, 100-400 Clark Ave, Detroit.

(A-24) **Sound Instruments**—Catalog, 4 pp. Describes portable sound level meter, analyzer, calibrating equipment and accessories. H H Scott, Inc, Instrument Div, 111 Powder Mill Rd, Maynard, Mass.

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(A-26) **Submersible Pumps**—Bulletin, 4 pp. Illustrates typical installations of gear and screw types. Sier-Bath Gear & Pump Co, Inc, 9252 Hudson Blvd, Bergen, NJ.

(A-27) **Drafting Machine**—Catalog, 16 pp. Describes models for horizontal or vertical drafting. Also shows scales. V & E Mfg Co, 766 S Fair Oaks Ave, Pasadena, Cal.

(A-28) **Counting Devices**—Catalog, 4 pp. Presents specifications of standard manual, mechanical, electrical and electronic counters for built-in or plant applications. Veeder-Root, Inc, 70 Sargeant St, Hartford, Conn.

(A-29) **Vapor Conservation Balloon**—Brochure, 4 pp. Describes rubber coated nylon balloon which attaches to storage tank to minimize vaporization and prevent escape of vapors. Reeves Bros, Inc, Vulcan Rubber Products Div, 1071 Sixth Ave, NYC 18.

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(A-31) **Electronic Test Equipment**—Catalog, 50 pp. Presents instruments for measuring phase, impedance, voltage, transmission or delay. Also includes poten-

tiometer test equipment, dual speed drives and others. Acton Laboratories, Inc, 553 Main St, Acton, Mass.

(A-32) Aluminum and Zinc Alloy Die Castings—Brochure, 6 pp. Describes services available. Includes tables of alloy average properties. Advance Tool & Die Casting Co, 3760 N Holton St, Milwaukee 12, Wisc.

(A-33) Wheels and Casters—Catalog, 27 pp. Provides dimensions and load ratings for standard and heavy duty models with solid tread or tires. Includes shock absorbing types. Aerol Co, Inc, 3285 San Fernando Rd, Los Angeles.

(A-34) Stainless Steel Products—Brochure, 19 pp. Illustrates facilities, personnel; standard and representative customer-specified products. Alloy Products Corp, 1045 Perkins Ave, Waukesha, Wisc.

(A-35) Polyethylene Fume Hood and Exhaust Systems—Bulletin, 4 pp. Describes exhaust and ventilating systems made of polyethylene, for handling corrosive materials in the form of air and vapors. American Agile Corp, Box 168, Bedford, Ohio.

(A-36) Data Tape Recorder—Brochure, 10 pp. Describes recorder capable of response to 250 kc at 60 ips. Utilizes solid state modular design circuitry. Records f-m or direct. Ampex Corp, Ampex Data Products Co, 934 Charter St, Redwood, Cal.

(A-37) Tape Recorder - reproducers – Brochure, 20 pp. Instrumentation recorder can operate at choice of four of six speeds up to 60 ips. Four recording techniques available. Ampex Data Products Co, 934 Charter St, Redwood City, Cal.

(A-38) Mockups—Brochure, 32 pp. Illustrates capabilities for making scale models, full-size mockups, training aids. Atkins & Merrill, Inc, Boston Post Rd, S Sudbury, Mass.

(A-39) Metal Hose—Catalog, 8 pp. Provides specifications and construction details for stripwound and corrugated hose. Includes illustrations of fittings and coupling. Atlantic Metal Hose Co, Inc, 308 Dyckman St, NYC 34.

(A-40) Degreasers and Industrial Ovens—Catalog, 12 pp. Provides illustrations and specifications of standard and special ovens and vapor degreasers. Baron Industries, 241 West Ave 26, Los Angeles 31.

(A-41) Swivel Chain—Catalog, 12 pp. Illustrates sizes and end fittings plus applications. The Bead Chain Mfg Co, 110 Mountain Grove St, Bridgeport 5, Conn.

(A-42) Hand Tools—Catalog, 64 pp. Illustrates wrenches, pliers, pullers, feeler gages and others. The Bingham-Herbrand Corp, 1111 Stone St, Fremont, Ohio.

(A-43) Instrument Components—Catalog, 62 pp. Presents drawings, specifications, dimensions of precision components such as speed reducers, servo motor gearheads, servo packages and counters, including navigational types. Bowmar Instrument Corp, 8000 Bluffton Rd, Ft Wayne, Ind.

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(A-46) Electronics Enclosures—Catalog, 48 pp. Describes sheet metal relay racks, cabinets, chassis and components. Bud Radio, Inc, 2118 E 55 St, Cleveland 3.

(A-47) Printed Circuit Drafting Aids—Brochure, 8 pp. Shows pasteups for laying out preliminary designs. By-Buk Co, 4314 W Pico Blvd, Los Angeles 19.

(A-48) Drawing Equipment—Catalog, 20 pp. Shows scales, templates, triangles, lettering guides, other aids. The C-thru Ruler Co, 827 Windsor St, Hartford 5, Conn.

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(A-50) Visual Aids—Catalog, 24 pp. Illustrates tapes, templates and other products for making graphs, charts or layouts. Chart-Pak, Inc, River Rd, Leeds, Mass.

(A-51) Aluminum Plugs and Caps—Catalog, 8 pp. Lists dimensions and prices for shipping closures. Clover Industries, Inc, 578-588 Young St, Tonawanda, NY.

(A-52) Plastic Plugs and Caps—Catalog, 12 pp. Provides dimensions, prices and materials characteristics for shipping closures. Clover Industries, Inc, 578-588 Young St, Tonawanda, NY.

(A-53) Stainless Steel Valves—Catalog, 103 pp. Contains drawings, dimensions, materials breakdown of valves, fittings, accessories for corrosive service in chemical, paper, petrochemical industries. Cooper Alloy Corp, Bloy St, Hillside, NJ.

(A-54) Photocopiers—Data folder, 10 pp. Describes machines that can make copies on regular paper, cards, tissue, transparent paper or film. Copies or originals can be double-sided. Also copy from books. Copease Corp, 425 Park Ave, NYC 22.

(A-55) Whiteprinters—Brochure, 6 pp. Describes machines from small desk models to 75 fpm automatics. Copymation, Inc, 5640 N Western Ave, Chicago.

(A-56) Decorative Metal and Glass—Catalog, 8 pp. Show range of patterns, finishes, colors, materials. Includes data on printed circuits. Croname, Inc, 6285 Howard St, Chicago 48.

(A-57) Aircraft and Test Equipment—Brochure, 12 pp. Has brief specifications of everything from rockets to blowers to automatic checkout equipment. Curtiss-Wright Corp, Santa Barbara Div, 6767 Hollister Ave, Goleta, Cal.

(A-58) Machining Service—Brochure, 12 pp. Outlines work capability of company. Lists machine facilities in detail. Custom Tool & Mfg Co, 2201 N Second St, Minneapolis, Minn.

(A-59) Industrial Fans—Bulletin, 16 pp. Furnishes tables and guides to selection of fans with capacities to over 38,000 cfm. The Day Co, 810 Third Ave NE, Minneapolis 13.

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(A-65) Copying Machines—Brochure, 16 pp. Machines make copies on bond, cards, translucent paper or four page forms. Also make two-sided copies, offset masters. Can copy from books. Eastern Kodack Co, 343 State St, Rochester, NY.

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catalogs and bulletins.....continued

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(A-69) Heating Mesh—Brochure, 16 pp. Wire mesh is laminated with insulator. Thermal and electrical formulas for the elements are given. Electrofilm, Inc, Box 106, N Hollywood, Cal.

(A-70) Film Heating Elements—Brochure, 12 pp. Heating element and insulation spray on. Gives thermal, physical and electrical characteristics. Electrofilm, Inc, Box 106, N Hollywood, Cal.

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(A-74) Metal Fabrication—Catalog, 25 pp. Presents standard consoles, racks, cabinets and custom service for making other similar products. Falstrom Co, Falstrom Court, Passaic, NJ.

(A-75) Stamping Service—Bulletin, 6 pp. Outlines capabilities for producing short runs in both metals and nonmetals. Includes stamping design helps. Federal Short Run Stamping Co, 3621 Alabama Ave, Minneapolis, Minn.

(A-76) Thread Compound—Bulletin, 4 pp. Describes high temperature compound for sealing and preventing seizing of bolts, studs. Felt Products Mfg Co, 7450 N McCormick Blvd, Skokie, Ill.

(A-77) Automatic Test Equipment—Brochure, 24 pp. Equipment uses punched tape for programing missile, aircraft or ground electronic systems tests. Readout is by lights and indicators or by permanent record. Stromberg-Carlson Div of General Dynamics Corp, 100 Carlson Rd, Rochester 3, NY.

(A-78) Telephone Handsets—Brochure, 8 pp. Shows wiring diagrams and contact combinations. Can be used in any voice communications system. Stromberg-Carlson Div of General Dynamics Corp, 100 Carlson Rd, Rochester, NY.

(A-79) Drafting Table—Brochure, 8 pp. Presents method of attaching drawing to endless belt as special feature to enable making large drawings on a small table. General Fireproofing Co, E Dennick Ave, Youngstown 1, Ohio.

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(A-83) Continuous Printers—Brochure, 8 pp. Describes automatic equipment for copying from original drawings, roll microfilm or aperture cards. Haloid Xerox Inc, 2-20 Haloid St, Rochester, NY.

(A-84) Casters and Wheels—Catalog, 15 pp. Gives load capacities and dimensions for single, double-wheeled, shock-absorbing, pneumatic tired and other types with capacities to 3000 lbs. The Hamilton Caster & Mfg Co, 1633-1697 Dixie Highway, Hamilton, Ohio.

(A-85) Casters and Wheels—Catalog, 16 pp. Dimensions and load ratings are given. Includes shock-absorbing, pneumatic tired types. The Hamilton Caster & Mfg Co, 1739 Dixie Hwy, Hamilton, Ohio.

(A-86) Drafting Equipment—Catalog, 38 pp. Describes boards, tables, files, combination units. Hamilton Mfg Co, Two Rivers, Wisc.

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(A-89) TV and Film Equipment—Catalog, 80 pp. Describes film processors, laboratory accessories, studio equipment, remote controlled antennas, camera heads. Houston Fearless Corp, 11801 W Olympic Blvd, Los Angeles.

(A-90) Vibrating Dryers—Catalog, 32 pp. Describes principles of operation, capacities, weights and power requirements of vibrating dryers, coolers, conveyors and auxiliary equipment. Suggests applications and combinations. The Jeffrey Mfg Co, Columbus 16, Ohio.

(A-91) Thread Gages and Comparators—Catalog, 16 pp. Provides descriptions of inspection methods and inspection equipment. The Johnson Gage Co, 534 Cottage Grove Rd, Bloomfield, Conn.

(A-92) Slide Mechanisms—Catalog, 124 pp. Provides dimensioned drawings, capacity vs travel curves for ball bearing slides with capacities from 50 to 800 lbs. Jonathan Mfg Co, 720 E Walnut Ave, Fullerton, Cal.

(A-93) Electronics Instruments—Bulletin, 6 pp. Provides specifications for equipment to measure vibration amplitude, microwave power, capacitance, impedance comparisons and other parameters. Wayne Kerr Corp, 1633 Race St, Philadelphia.

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(A-96) Drafting Equipment—Catalog, 49 pp. Shows pens, pencils, crayons, lettering guides, erasers, sharpeners and other accessories. Koh-I-Nor Pencil Co, Inc, Bloomsbury, NJ.

(A-97) Metal Working Services—Bulletin, 4 pp. Describes services such as stress relieving, testing, finishing, stamping and others available on a contract basis. Koven Fabricators, Inc, 90 E Dickerson St, Dover, NJ.

(A-98) Processing and Storing Equipment—Shows specialized equipment that fabricator can make. Some past jobs include kettles, towers, tanks, retorts, pressure vessels and stacks. Can work with any metal plate ¼ to 1¼ in. thick. Koven Fabricators, Inc, 90 E Dickerson, Dover, NJ.

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GENERAL ENGINEERING

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catalogs and bulletins.....continued

(A-99) Metal Fabricator—Bulletin, 8 pp. Shows resources for fabricating specialized equipment for processing, plant operation, handling or storing. Koven Fabricators, Inc, 90 E Dickerson, Dover, NJ.

(A-100) Electronics Instruments—Catalog, 6 pp. Describes variable electronics filters, laboratory power amplifiers, RC oscillators, regulated power supplies. Krohn-Hite Corp, 580 Massachusetts Ave, Cambridge 39, Mass.

(A-101) Name Plates and Trim—Brochure, 8 pp. Gives sizes, finishes, fastening methods. LaFrance Precision Casting Co, 29th & McKean St, Philadelphia.

(A-102) Avionics—Brochure, 6 pp. Describes air and missile craft electronic subsystems components such as power supplies, servo amplifiers. Lear, Inc, Astronics Div 3171 S Bundy Dr, Santa Monica, Cal.

(A-103) Reference Books—Bulletin, 4 pp. Describes in detail four important design reference books: *Product Engineering Design Manual, Handbook of Fastening and Joining Metal Parts, Fluid Power Controls* and *Engineering Materials Handbook*. McGraw-Hill Book Co, Inc, 330 W 42nd St, NYC 36.

(A-104) Strainers—Catalog, 8 pp. Describes strainers, blinds, spacer rings, pivot flanges for use in petroleum and chemical industries. The Mack Iron Works Co, 125 Warren St, Sandusky, Ohio.

(A-105) Wire Rope—Brochure, 4 pp. Presents weights, strengths and construction for sizes from $\frac{5}{16}$ to $3\frac{1}{4}$ in. OD. Macwhyte Wire Rope Co, 2940 14 Ave, Kenosha, Wisc.

(A-106) Nameplates—Brochure, 15 pp. Shows facilities for manufacturing etched, embossed, lithographed nameplates, dog tags, badges and bronze tablets. George J Mayer Co, Inc, 546 E Market St, Indianapolis, Ind.

(A-107) Drafting Room Equipment—Catalog, 32 pp. Describes several styles of drafting tables, plan files, stools and straightedges. Mayline Co, Inc, 607 N Commerce St, Sheboygan, Wisc.

(A-108) Wire Forms—Brochure, 12 pp. Explains terms used when working with wire to help a person making up a specification. Also a wire gage chart. Merrill Mfg Co, Box 566, Merrill, Wisc.

(A-109) Packaging—Catalog, 8 pp. Describes protective packaging for electronic, optical or mechanical devices and instruments needing protection against heat, humidity, other unusual conditions. Includes detailed drawings of laminated construction. Zero Mfg Co, White Div, Inc, Palmer, Mass.

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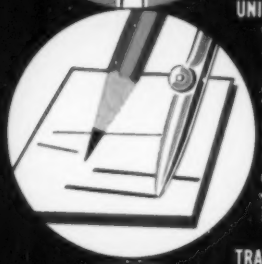

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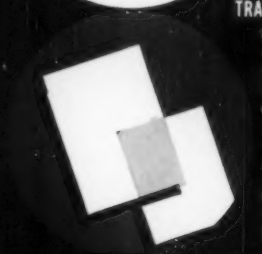

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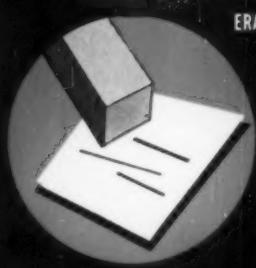

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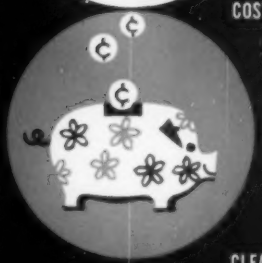

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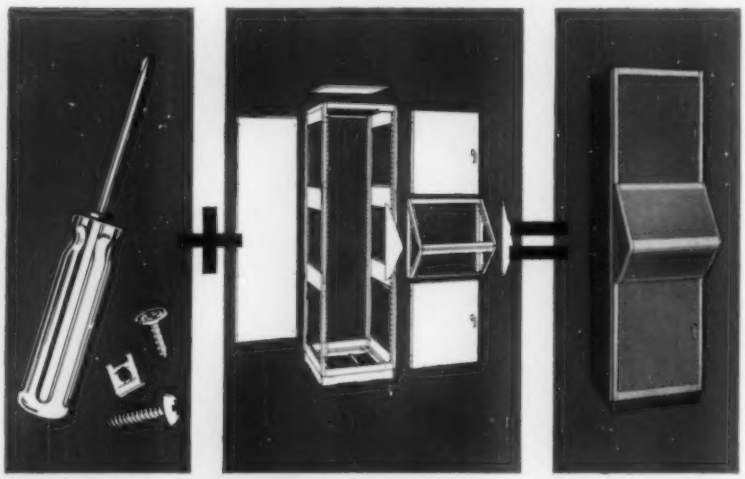

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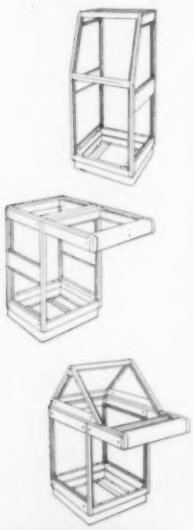

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(A-110) Hot Airless Spray Paint System—Brochure, 8 pp. Describes equipment, working principles, advantages and materials that can be applied. Nordson Corp, 86 Jackson St, Amherst, Ohio.

(A-111) Lifting Magnets—Bulletin, 8 pp. Describes controls and magnets including special types for wet work, hot pieces, extra rough work. Ohio Electric Mfg Co, 5#00 Dunham Rd, Maple Hts, Ohio.

(A-112) Valves—Catalog, 24 pp. Presents dimensions, construction and ratings of bronze, iron and steel industrial valves and accessories. The Ohio Injector Co, 275 Main St, Wadsworth, Ohio.

(A-113) Molded Rubber—Brochure, 6 pp. Describes manufacturing process and how to specify. Paeco Rubber Co, Inc, 226 W Lake St, Ravenna, Ohio.

(A-114) Blueprinting Machines—Brochure, 16 pp. Describes automatic, high production machines for seven different types of reproductions. C F Pease Co, 3816 N Rockwell St, Chicago 18.

(A-115) Whiteprinting Machines—Brochure, 8 pp. Describes large, automatic machine for reproducing translucent material. C F Pease Co, 3816 N Rockwell St, Chicago 18.

(A-116) Cold Drawn Shapes and Pinion Rod—Catalog, 16 pp. Provides dimensioned cross-section drawings, tables of materials, design considerations and sample applications. Rathbone Corp, Palmer, Mass.

(A-117) Bellows Joints—Brochure, 4 pp. Describes teflon bellows for expansion, flexible and vibration joints. Lists chemical resistant properties and working pressures and temperatures. Resistoflex Corp, Woodland Rd, Roseland, NJ.

(A-118) Drafting Equipment—Catalog, 136 pp. Describes such items as boards, lettering devices, planimeters, pantographs and others. Frederick Post Co, 3650 N Avondale Ave, Chicago 18.

(A-119) Drawing Media—Catalog, 44 pp. Shows tracing and drawing paper, cloth, film. Frederick Post Co, 3650 N Avondale Ave, Chicago 18.

(A-120) Sight Glasses—Brochure, 6 pp. Describes and illustrates sight glasses for high temperature and high pressure. Range is full vacuum to 22,000 psi. Pressure Products Co, Box 424, Charleston, W Va.

(A-121) Plastic Closures—Data Folder, 16 pp. Furnishes dimensions of protective polyethylene caps and plugs for protecting threads and open ends. Caplugs Div, Protective Closures Co, Inc, 2207 Elmwood Ave, Buffalo 23, NY.

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Quick replacement — malfunctioning component can be snapped out and replaced in seconds.

In-service checks — Alden Adapter Cable brings chassis out into the open while in operation for quick checking.

Single point of check — all leads brought to single checkpoint — makes possible color coded, vividly illustrated circuit legends.

Quick repair — rugged, portable carrying case protects chassis. Replacement of malfunctioning chassis is only air mail time away from service center.

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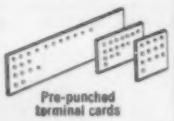

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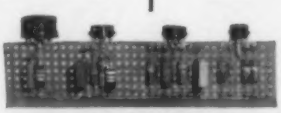
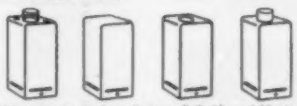


Complete circuits ready for plug-in package or chassis

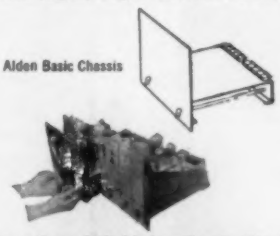
2

Mount cards in Alden Basic Chassis for tremendous variety with standard components — Alden provides standard plug-in or slide housings. With spares, units are replaceable in 30 seconds.



Alden plug-in package 4 sizes: 7, 9, 11, and 20 pin

Alden Basic Chassis



Picture Frame Rack Adaptor — for mounting Alden Basic Chassis in any combination. Mounts in standard rack or Alden UniRacks.

3

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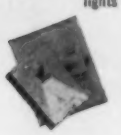

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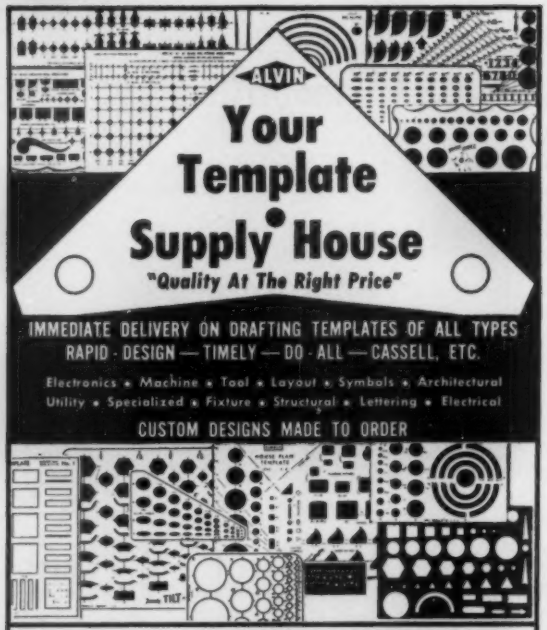
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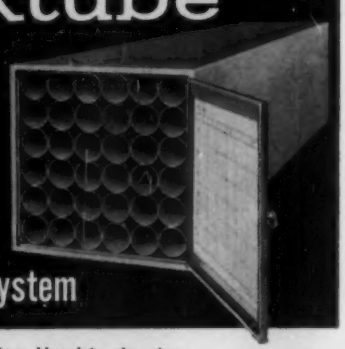

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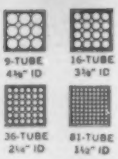

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(A-122) Pyrometers—Brochure, 8 pp. Provides descriptions, specifications, prices of optical, radiation, immersion, surface and indicating types. Pyrometer Instrument Co, Inc, 92 Portland Ave, Bergenfield, NJ.

(A-123) Metals Fabricator—Brochure, 28 pp. Illustrates facilities for making aluminum stampings and formings, aluminum and stainless steel rolled sections with chemical and mechanical finishes. Mirro Aluminum Co, Manitowoc, Wisc.

(A-124) Contract Manufacturing—Brochure, 4 pp. Explains facilities and services for supplying sheet metal products. Berger Div, Republic Steel Corp, 1038 Belden Ave NE, Canton, Ohio.

(A-125) Precision Sheetmetal Fabrications—Brochure, 26 pp. Describes capabilities for working stainless steel and super alloy sheetmetal. Also shows aviation and automotive high temperature brazing and heat treating. The Stalker Corp, 903 Woodside Ave, Essexville, Mich.

(A-126) Air Impellers—Bulletin, 4 pp. Illustrates and gives available sizes of blower wheels, fan blades, housings and inlet rings. Revcor Inc, 251 Edwards St, Carpentersville, Ill.

(A-127) Torque Wrench—Brochure, 6 pp. Describes wrench and gage for setting. Richmont Inc, 922 S Myrtle Ave, Monrovia, Cal.

(A-128) Steel Tubing—Brochure, 12 pp. Explains manufacturing of tubing and fabrication into assemblies. Gives finishes, sizes and tolerances. Rochester Products, Div of General Motors, 1000 Lexington Ave, Rochester, NY.

(A-129) Knobs and Handles—Catalog, 24 pp. Gives illustrations and dimensions of stock items made of molded thermosetting plastic. Rogan Bros, 8025 N Monticello Ave, Skokie, Ill.

(A-130) Blueprint Files—Brochure, 5 pp. Files carry 8 to 49 rolled up prints, and can be stacked to add capacity. Roll & File Systems, Inc, Box 3863, Detroit 5.

(A-131) Power Cords—Catalog, 48 pp. Shows molded plastic and rubber cords with 2, 3 and 4-wire connectors plus special electronic assemblies. Royal Electric Corp, Pawtucket, RI.

(A-132) Weather Seals—Catalog, 44 pp. Provides dimensioned drawings of woven pile seal assemblies for moving parts. Schlegel Mfg Co, Box 197, 1555 Jefferson Rd, Rochester 1, NY.

(A-133) Zinc Coating—Bulletin, 4 pp. Describes uses and properties of a compound which is applied like paint. The Sealube Co, 14 Valley St, Wakefield, Mass.

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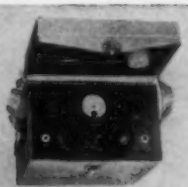

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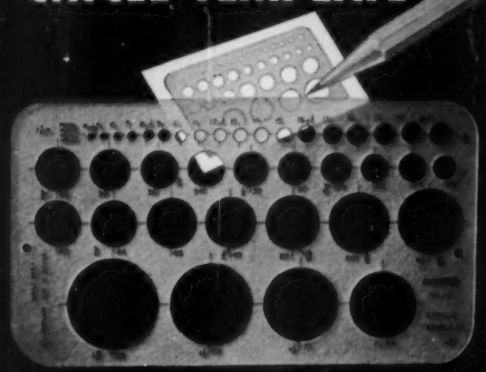

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(A-134) Drafting Room Equipment—Catalog, 24 pp. Describes drawing tables, tracing tables, blueprint files and other drafting room furniture. Stacor Equipment Co, 285 Emmet St, Newark 5, NJ.

(A-133) Glass-lined Pipe—Brochure, 8 pp. Describes construction and installation of pipe which can be cut to length in field. Pfaudler Div, Pfaudler Permutit Inc., 1000 West Ave, Rochester, NY.

(A-136) Hour Meters—Catalog, 4 pp. Shows ac and dc meters for recording running time. John W Hobbs Corp, Div of Stewart-Warner Corp, Yale Blvd & Ash St, Springfield, Ill.

(A-137) Reinforced Plastics—Bulletin, 4 pp. Presents typical parts and applications. Includes description of stock tanks. Structural Fibers, Inc, Fifth Ave, Chardon, Ohio.

(A-138) Glass Reinforced Plastics—Brochure, 4 pp. Explains advantages of the material and the capabilities of the plant. Structurlite Plastics Corp, 130 Newark Rd, Hebron, Ohio.

(A-139) Instrument Cases—Catalog, 20 pp. Explains construction and provides plans for standard models of aluminum cases. Lists finishes and tests. TA Mfg Corp, 4607 Alger St, Los Angeles 39.

(A-140) Airborne Refrigeration—Data folder, 10 pp. Shows pumps, water coolers, refrigeration units operating on 400 cps power. Task Corp, 1009 E Vernont Ave, Anaheim, Cal.

(A-141) Reproduction Equipment—Catalog, 48 pp. Describes diazo type process, machinery, and papers, cloth and film reproducing materials. Tecnifax Corp, 195 Appelton St, Holyoke, Mass.

(A-142) Extreme Temperature Insulation—Catalog, 34 pp. Illustrates capabilities for making high and low temperature insulation, especially in aircraft and missile fields. H I Thompson Fiber Glass Co, 1733 Cordova St, Los Angeles 7.

(A-143) Surface Hardened Rod—Catalog, 8 pp. Presents specifications of material and capabilities of the fabricators. Thomson Industries Inc, Manhasset, NY.

(A-144) Drafting Machine—Brochure, 10 pp. Describes large size and powered machines with protractor mounted in tracks. Any length offered. Universal Drafting Machine Corp, 7960 Lorain Ave, Cleveland.

(A-145) Metal Tubing and Shapes—Catalog, 48 pp. Illustrates full size over 500 cold formed metal shapes for which rolls and dies are on hand. Van Huffel Tube Corp, Warren, Ohio.

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(A-147) Gear Pumps—Bulletin, 10 pp. Contains selection tables, dimensions and construction details of pumps for handling oils and chemicals up to 100,000 SSU viscosity; pressures to 250 psi, capacities to 1000 gpm. Warren Pumps, Inc, Warren, Mass.

(A-148) Thermoplastic Knobs—Brochure, 6 pp. Presents dimensioned drawings of sample selection of standard knobs. Waterbury Companies, Inc, Box 1032, Waterbury, Conn.

(A-149) Thermosetting Knobs—Brochure, 8 pp. Presents dimensioned drawings of sample selection of standard plastic knobs. Waterbury Companies, Inc, Box 1032, Waterbury, Conn.

(A-150) Environmental Chambers—Brochure, 28 pp. Describes chambers to furnish —125F to 600F atmospheres; pressure altitudes to 100,000 ft; 20 to 95% humidity. Webber Engineering Corp, Box 217, Indianapolis, Ind.

(A-151) Fans—Catalog, 28 pp. Provides tables of dimensions, hp, cfm, rpm and other parameters for choosing fan wheels and hoods for moving gases and materials. Westinghouse Electric Corp, Sturtevant Div, Hyde Park, Boston.

(A-152) Electric Welded Steel Tubing—Bulletin, 4 pp. Tabulates gages, sizes and weights. Lists available types. Wheatland Tube Co, Bankers Security Bldg, Philadelphia 7.

(A-153) Conveyors—Brochure, 10 pp. Gives instructions for designing a wire belt conveyor system. Wire Belt Co of America, 19 River St, Winchester, Mass.

(A-154) Wire Conveyor Belting—Bulletin, 4 pp. Shows wire size, mesh and load capacity. Wire Belt Co of America, 19 River St, Winchester, Mass.

(A-155) Centrifugal Castings—Brochure, 4 pp. Describes process and facilities for making machined stainless and high alloy castings. Lists most popular alloys with properties and applications. Wisconsin Stainless Foundry & Machine Corp, 825 E St Paul Ave, Waukesha, Wisc.

(A-156) Clamps—Data sheets, 12 pp. Gives material, size specifications for hose, tubing, duct band clamps. Wittek Mfg Co, 4305-37 W 24 Pl, Chicago 23.

(A-157) Heat Exchangers—Catalog, 15 pp. Shows construction and specifications for tube and shell type. Includes tables, curves and sample calculations for making selection. Young Radiator Co, 709 S Marquette, Racine, Wisc.

(A-158) Aluminum Boxes—Catalog, 20 pp. Gives dimensions of round and rectangular boxes and covers. Zero Mfg Co, 1121 Chestnut St, Burbank, Cal.

(A-159) Magnesium Boxes—Catalog, 24 pp. Lists dimensions of rectangular boxes, covers and instrument cases. Zero Mfg Co, 1121 Chestnut St, Burbank, Cal.

(A-160) Aluminum Instrument Cases—Catalog, 12 pp. Shows construction and lists dimensions of military cases. Zero Mfg Co, 1121 Chestnut St, Burbank, Cal.

(A-161) Instrument Housings—Catalog, 4 pp. Provides dimensioned drawings, specifications for aluminum case styles available. Zero Mfg Co, 1121 Chestnut St, Burbank, Cal.

(A-162) Modular Packaging—Catalog, 16 pp. Shows construction of sealed, shock-resistant humidified aluminum shipping containers for any size object. Zero Mfg Co, 1121 Chestnut St, Burbank, Cal.

(A-163) Carrying Cases—Catalog, 4 pp. Presents dimensions and specifications of commercial, dust and spray-tight aluminum cases for electronic instruments. Zero Mfg Co, 1121 Chestnut St, Burbank, Cal.

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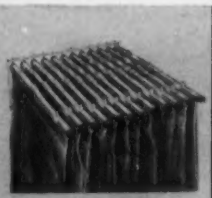

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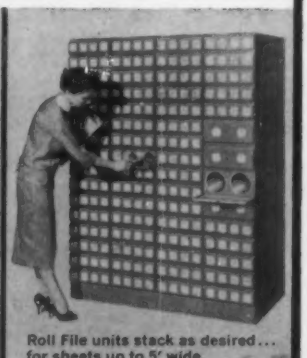

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SECTION B

METALS AND ALLOYS

Design Abstracts 58

A Look at Copper Corrosion 60

Cross-reference Charts for Die-casting Alloys 63

Austenitic "Cold Working" for Ultra-strength Steel
by D. J. Schmatz, J. C. Shyne and V. F. Zackay 64

For High Temperatures These Metals for Magnets 67

Chemical Resistance of Zirconium, Titanium, Tantalum and 316-Stainless Steel 68

Spring Material at High Temperature 69

Beryllium—What It Can Do and How It Can Be Worked 70

DESIGN ABSTRACTS

CORRUGATED-SANDWICH STRUCTURES

This paper describes the development of forming and joining techniques for corrugated-sandwich structure. Techniques developed include rolling, manual and automatic fusion welding, resistance spot welding, and tungsten-arc spot welding. Evaluation of welding methods is based on results of tensile-shear tests and metallographic examinations. Applicability of the techniques developed to other types of corrugated sandwich-structure assemblies is considered.

"Developing of Forming and Joining Techniques for Corrugated-sandwich Structure," H. Smallen and R. P. Romaine, Materials Research Laboratory, Norair Div, Northrop Corp, Hawthorne, California. Welding Journal, April 1960, 20th and Northampton Streets, Easton, Penna.

*

Low-friction Metals

A very low friction, about 10^{-3}, has been unexpectedly observed in reciprocating sliding of gold, silver, copper, and platinum. It was found that characteristics common to those metals were soft metal substrate and no surface oxide or soft oxide.

"Low Friction of Metals in Reciprocating Sliding," Yasukatsu Tamai, Aeronautical Research Institute, Meguro, Tokyo, Japan. Journal of Applied Physics, Dec '59, 335 E 45th St, New York 17.

*

Permanent Magnet Materials

While the bulk of the present-day requirements for permanent magnets are met by the aluminum-nickel dispersion-hardening alloys with their high nagnetic properties, i.e., the anisotropic Alcomax alloys and the isotropic alloys Alni and Alnico, these are subject to serious mechanical limitations and are only suitable for fabrication in cast or sintered forms with geometric restrictions. Thus a demand for alloy steel magnets continues, particularly where complexity of shape or intricacy of machining makes it impossible to employ magnets from the newer alloys and where reasonable, rather than outstanding, magnetic properties are called for. More recently, too, considerable advances have been made in the production of nonmetallic or co-called "ceramic" magnets based on ferrities. The high coercivity of these materials permits very short length/section ratios, although remanence is low and the temperature characteristics unfavorable. Seven tables of materials are included.

"How to Select Permanent Magnet Materials," R. H. Warring. Engineering Materials and Design, April 1960, Drury House, Russell St, London, W.C. 2, England.

*

Fractures in Aluminum

An understanding of fracture patterns often will give a valuable clue as to the cause of failure of a welded joint. Defects in weld metal, such as hot cracks and crater cracks, will exhibit a fracture pattern quite unlike that of sound weld metal. The purpose of this paper is to help the observer recognize this unusual pattern and to understand its significance.

"How to Interpret Fractures in Aluminum Weld Metal," William L. Burch, Bell Aircraft Corp, Buffalo, NY. Welding Journal, Apr '60, 20th and Northampton Streets, Easton, Penna.

*

Factors Influencing Corrosion

Both external (such as pH of solution, stray electric current inhibitors and stimulants) and internal (position in periodic table, stresses and surface conditions) factors influencing rate and distribution of corrosion are discussed.

"Factors Influencing Corrosion," G V Akimov, Chapter 5 of book, "Theory and Research Methods of Metallic Corrosion" (USSR). Corrosion, Sept 1959, 1061 M & M Building, Houston.

*

Creep Resistance of Molybdenum

Results of high-temperature compressive and tensile creep tests on single and polycrystalline specimens of molybdenum are given. Effect occur in four stages: random orientation, metastable locking, substructure formation, substructure coarsening.

"Effect of Prestrain and Polygonization on Creep Resistance of Molybdenum," Iannucci, Intrater and Weinig, Materials Research Corp; American Institute of Mining and Metallurgical Engineers, 29 W 39th St, New York 18.

*

Creep Resistance

Properties of alloys offering good resistance to creep; testing procedures and factors influencing material selection are discussed.

"Choosing Metals and Alloys for Creep Resistance," M. G. Gemmill, Central Electricity Governing Board (Great Britain); Engineering Materials and Design, Nov '59, Drury House, Russell St, London, WC 2, England.

*

Information on Magnetostriction

59 pages of abstracts from technical literature on the subject, from 1900 to 1959.

"Informative Abstracts on Magnetostriction in Cobalt and Cobalt Alloys," Ellis Fletcher, Battelle Memorial Institute. Cobalt Information Center, 505 King Ave, Columbus 1, Ohio.

*

Metals at High Temperatures

The newer high-temperature test methods of determining elastic moduli, tensile behavior at high strain rates, and hot hardness are described and experimental data analyzed. Effects of grain size, composition, and various transformations are discussed. Relationships between hardness and tensile strength, creep and creep-rupture behavior are summarized.

"Survey of Various Special Tests Used to Determine Elastic, Plastic and Rupture Properties of Metals at Elevated Temperatures," F. Garofalo, US Steel Corp; ASME paper 59-A-112, ASME 29 W 39th St, New York 18.

*

Structure Foil

An all-spot-welded, foil-gage, structural material for elevated temperatures, stiffened by corrugation, is described. Strength is equivalent to

double-skin brazed sandwich construction of equivalent weight. Sample products and some design problems are discussed.

"Structural Foil for Hot Parts," M. J. Bretenbach and Brooks Lake, Ryan Aeronautical Co. Society of Automotive Engineers paper 99T, 485 Lexington Ave, New York 17.

*

Acoustic Fatigue Characteristics of Aluminum Panels

Panels 11 x 13 in. of 2024-T3 aluminum were exposed to discrete noise from a siren and random noise from and air jet, with noise levels varying from approximately 140 to 161 db. Panel variables included thickness, edge condition, curvature, static pressure differential.

Differences in failure times are given as a function of noise level and panel thickness, curvature and static pressure. Feasibility of locating weak points in panels by this means and of predicting fatigue life are discussed.

"A Study of the Acoustic Fatigue Characteristics of Some Flat and Curved Aluminum Panels Exposed to Random and Discrete Noise," Hess, Herr and Mayes, Langley Research Center, NASATN D-1. National Aeronautics and Space Administration, Washington 25, D. C.

*

Design of Heavy-duty Iron Castings

After a brief description of foundry practice, such factors as reduction of stresses in castings, designing for minimum cost, designing for optimum ease of machining are discussed. A page of drawings gives some suggestions for design details.

"Design of High-duty Iron Castings," E. G. Donaldson, International Meehanite Co, Ltd. Engineering Materials and Design, April '60, Drury House, Russel St, London WC 2, England.

*

Manganese in Iron

Manganese has two important roles in iron and steel. It combines with sulphur to form manganese sulphile rather than iron sulphile. Iron sulphide is considered undesirable for two reasons. It solidifies after the main part of the iron and forms a film-type of inclusion around the eutectic cells (grain). This can materially embrittle the iron. (This condition would only result from extremely high sulphur contents possible about 0.25 or 0.30).

Also, iron sulphide is a strong carbide stabilizer and tends to make the thinner sections of a casting white. White iron stabilized by sulphur is so difficult to anneal that it is not usually practical.

"Better Properties at Less Cost—Via Manganese," Charles F. Walton, Technical Director, Gray Iron Founders' Society, Inc. Gray Iron News, September, 1959, National City-E. 6th Bldg, Cleveland 14, Ohio.

*

Eutectic Structure in Gray Iron

Some Russian work that was published in 1953 but has only recently come to attention provides a new and interesting insight into the mechanism of eutectic solidification in gray iron.

"Eutectic Structures in Gray Iron," by Professor John F. Wallace, Case Institute of Technology. Gray Iron News, December, 1959, National City-E. 6th Bldg, Cleveland, 14, Ohio.

*

Keeping Corrosion Out of Aluminum Structures

Although aimed primarily at designers of transportation equipment, basic considerations should apply to other types of products for use outdoors or with harmful liquids. Included in discussion are some data on choice of materials, joint design, provision for drainage and other factors.

"Tips on Making Aluminum Structures Corrosion-free," Weltman and Bast, Aluminum Co of America. SAE Journal, March '60, 485 Lexington Ave, New York 17.

*

Titanium-clad Steel

Because titanium resists corrosion by nitric acid, wet chlorine, sea water, and many other corrosive liquids, it is of great interest to the chemical, food, and other process industries. However, the high price of solid titanium restricts its use. The obvious answer is cladding. If steel could be successfully clad with a layer of titanium, this would offer not only considerable cost savings to potential users, but also a greater variety of gage and size of plates which are not available in titanium mill products alone. This article is a progress report.

"Cladding Steel With Titanium . . . A Progress Report," J. L. Ma and C. Wright, Jr., Research Dept, Lukens Steel Co, Coatesville, Pa. Metal Progress, May 1960, Metals Park, Novelty, Ohio.

*

Fractures in Aluminum

An understanding of fracture patterns often will give a valuable clue as to the cause of failure of a welded joint. Defects in weld metal such as hot cracks and crater cracks will exhibit a fracture pattern quite unlike that of sound weld metal. The purpose of this paper is to help the observer recognize this unusual pattern and to understand its significance.

"How to Interpret Fractures in Aluminum Weld Metal," William L. Burch, Bell Aircraft Corp, Buffalo, NY. Welding Journal, April 1960, 20th and Northampton Streets, Easton, Pa.

*

Mechanical Properties of Metals in Design

How to use test results of such properties as fatigue, selective corrosion, brittle fracture and other major causes of failure is described. Tensile strength is also discussed, along with hardness and various types of impact testing procedures.

"Significance of Mechanical Properties of Metals in Design," D. Birchon, Admiralty Materials Laboratories. Engineering Materials and Design, Aug-Sept 1959, Drury House, Russell St, London WC 2, England.

*

Gear Materials

Ten alloys, eight of them commercially available and including tool, die and other steels and titanium, were tested in a device patterned after a Kelley roll tester to evaluate resistance to scoring at 700 F. Results obtained indicate that resistance correlates fairly well with surface hardness.

"Evaluation of Gear Materials Scoring at 700 F," Jackson, Muench, Scott, General Electric Co. American Society of Lubrication Engineers paper 591C-6, 5 N Wabash Ave, Chicago 2, Ill.

From: Company Bulletin

This rundown of how electro-chemical and mechanical action can cause trouble will help when it becomes necessary to take . . .

A LOOK AT COPPER CORROSION

In order to make proper choice of a metal, it is necessary not only to evaluate the conditions under which it will be used but also to know what type of corrosion may be expected on certain alloys under these conditions. Here is a rundown of the various types of corrosion to watch out for in copper and copper alloys.

DEZINCIFICATION

Dezincification is a type of corrosion in which brass dissolves as an alloy and copper redeposits as a metal but in a porous form. The zinc constituent of the brass may be carried away as solution zinc salts by the corroding solution or may be deposited in place in the form of insoluble zinc compounds. Dezincification corrosion may proceed uniformly or locally. The former, called layer-type dezincification, most often occurs in acid environments. The latter, called plug-type dezincification, most often occurs in alkaline, neutral or slightly acid environments.

Copper-zinc alloys of duplex or two-phase grain structure often dezincify in two stages. The zinc-rich beta grains are dezincified first; then as corrosion proceeds the alpha grains become dezincified. The several types of dezincification are illustrated in Figures 1, 2 and 3.

High temperature and low velocity of the corrosive environment accelerate dezincification corrosion. Brasses containing not more than 15% zinc are highly resistant to dezincification. In the development of admiralty and naval brass for sea water applications, an addition of tin was found to have some effect in reducing dezincification corrosion. Arsenic, however, is more effective and a nominal 0.04% of this element is now added to admiralty and aluminum brass to inhibit dezincification. Arsenic is not useful in alpha-beta brasses, because it does not inhibit dezincification of the beta phase.

PITTING AND DEPOSIT CORROSION

Pitting corrosion is localized accelerated attack resulting in the formation of cavities around which the metal is relatively unattacked. Pitting is due to the occurrence of strongly anodic areas which may be set up by widely differing factors.

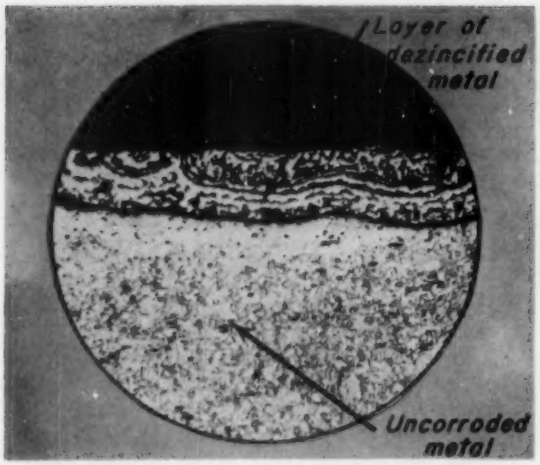
Deposit corrosion is a form of pitting that occurs under porous deposits of corrosion products or deposits of foreign matter. Metal beneath a deposit becomes anodic to metal away from the deposit. The mechanism has been attributed to differential aeration, in which the anode of the cell is an area shielded from oxygen (air). Since copper alloys are highly resistant to differential aeration corrosion other factors may be involved in deposit attack; in any case, this type of pitting is an infrequent cause of failure of these alloys. An example of deposit corrosion is shown in Figure 4. This pit formed in the wall of an uninhibited admiralty condenser tube where the sea water used for cooling contained paper pulp. Pulp settling on the tube wall was the deposit. The relatively large particles in the pit are crystals of redeposited copper which may have been formed because the pump maintained a high copper-ion concentration in that area.

IMPINGEMENT CORROSION

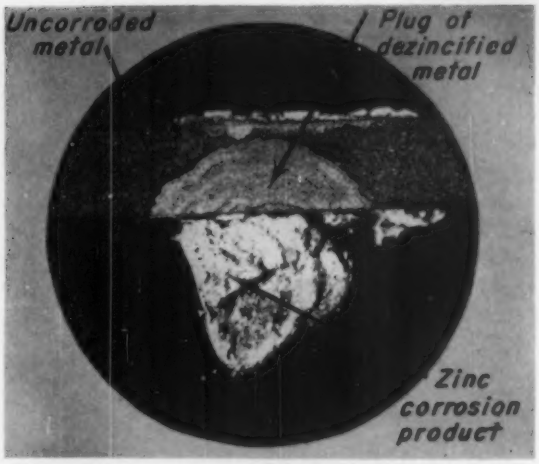
Another type of pitting, called impingement corrosion or corrosion-erosion, is caused by the turbulent flow of a solution over a metal surface. Protective films are thereby removed or prevented from forming. Pits are often in the form of "horse-shoes" with the toe pointing in the upstream direction, although sometimes elongated pits are formed which tend to be undercut on the downstream end. Air bubbles which are large enough to be either broken up or readily distorted by changes in pressure at the surface of a metal act as accelerators of this type of corrosion. Actively corroding impingement pits are free from corrosion products. Impingement corrosion may occur where water, fresh or salt, or chemical solutions flow turbulently over or against a metal surface, but this type of corrosion is most often encountered in tubes in condensers and heat exchangers handling sea water at excessive velocities. Figure 5 illustrates this type of corrosion.

STRESS-CORROSION CRACKING

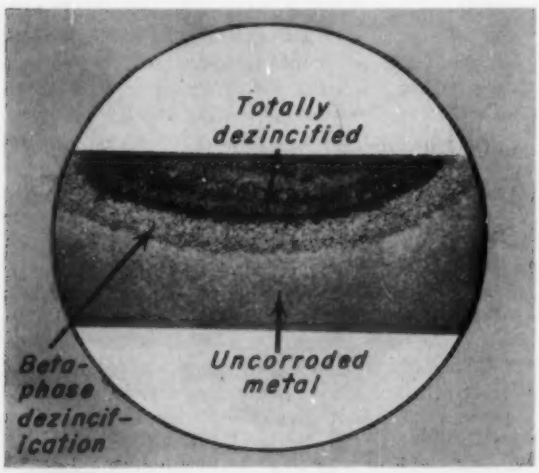
Stress-corrosion cracking (often called "season cracking") is the cracking of metal from the combined action of localized corrosion and stress, residual or applied. Residual stresses are those that remain as the result of cold deformation; applied stresses are those that are set up and exist due to an external load. Moist ammonia in the presence of air is the cause of stress-corrosion cracking of copper alloys. The limiting amount of ammonia in the atmosphere causing stress-corrosion cracking is not known, but it is known that only very small amounts are necessary when the other factors contributing to this type of failure are present. The source of ammonia need not be a leak in equipment holding ammonia but can be the bacterial decomposition of moist organic matter. Stress-corrosion cracks in copper alloys generally follow an intergranular path but in some cases the cracks are transcrystalline. These two types are illustrated in Figures 6 and 7.



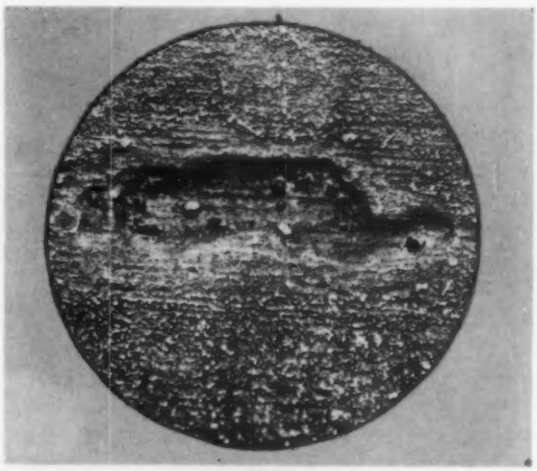
1. **LAYER-TYPE** dezincification of Leaded Yellow Brass in contact with sea water 20 months. 55X



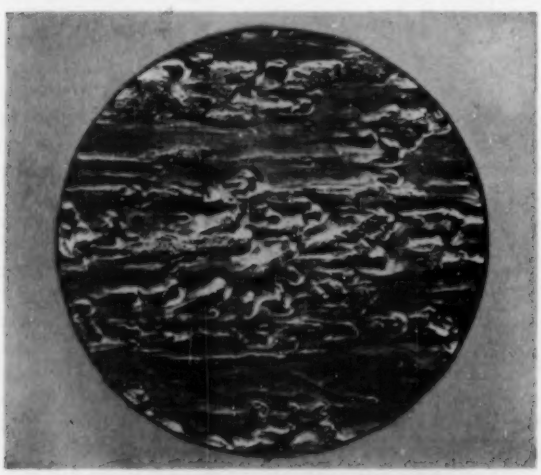
2. **PLUG-TYPE** dezincification of Yellow Brass in contact with fresh water. 4.4X



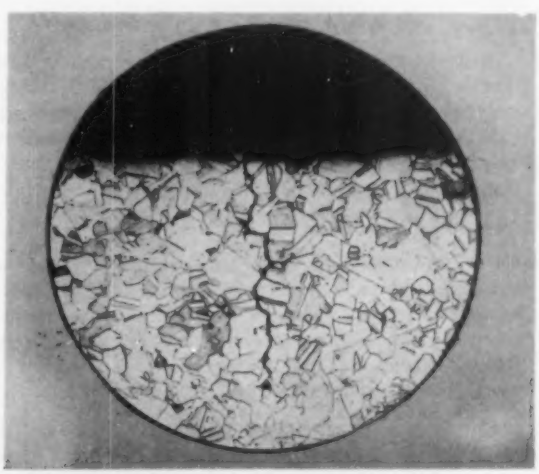
3. **TWO-STAGE** dezincification of Munts Metal in contact with fresh water. 7.3X



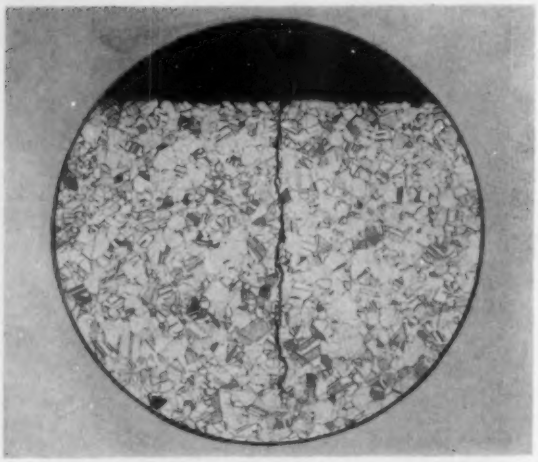
4. **DEPOSIT PITTING** in uninhibited Admiralty condenser tube. 7.3X



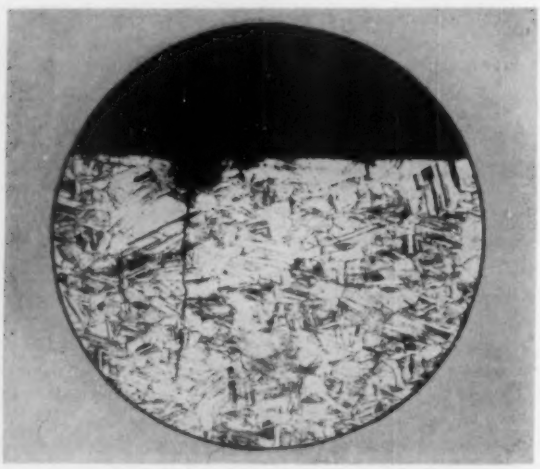
5. **IMPINGEMENT CORROSION** on the inside of an Admiralty Brass condenser tube from a ship's condenser operating with a high sea-water velocity. Direction of water flow, right to left. 4.4X



6. **INTERGRANULAR STRESS-CORROSION** cracking of 70-30 Brass tube from oil refinery heat exchanger. This is the general path taken by stress-corrosion cracks in brass. 64X



7. TRANSCRYSTALLINE STRESS-CORROSION cracking of Admiralty tube from refinery oil cooler. 48X



8. CORROSION-FATIGUE cracking of an Aluminum Brass condenser tube after three months service in a power station condenser. 48X

Studies in the laboratories of The American Brass Company have indicated that all copper alloys may stress-corrosion crack under certain conditions, but brasses containing more than 15% zinc are more subject to this phenomenon; these conclusions have been corroborated by service experience.

Stress-relief annealing

The cracking of brasses by stress corrosion due to residual stresses from cold forming can be avoided by heating the formed article at about 527 F to 572 F for one-half hour. This does not appreciably affect the physical properties of the alloy. Other copper alloys may require an anneal at higher temperature and less time.

CORROSION FATIGUE

The simultaneous action of cyclic stresses and corrosion may result in cracking failure called corrosion fatigue. Failure occurs by the propagation of transcrystalline cracks which often start at pits that act as stress raisers. Cracks caused by corrosion fatigue may be differentiated from transcrystalline stress-corrosion cracks because the former often show indications of slight work-hardening in the vicinity of the crack. Condenser tubes that have failed in this manner often show abrasion marks where the vibrating tube has rubbed against a neighboring tube. A typical corrosion-fatigue crack is shown in Figure 8.

GALVANIC CORROSION

Corrosion that occurs when dissimilar metals are in contact in the presence of an electrolyte is called galvanic corrosion. The standard potential or the position of a metal in the electromotive series does not always indicate how dissimilar metals will behave when coupled together. Whether a metal in contact with another metal will corrode or cause the other metal to corrode depends on many factors, among which are the electrical conductivity of the solution, the presence of air or an oxidizing agent, the relative tendency of the metals to go into solution, and the polarization characteristics of the metals. For example, galvanic corrosion will be slight in a neutral, distilled water compared to the galvanic corrosion in an acid solution. Galvanic corrosion of the metals commonly used in hot water heating systems is not significant because the air is removed from the water on heating and is vented.

The important effect of polarization on galvanic corrosion is illustrated by tests made in the laboratories of The American Brass Company indicating that cupro nickels in contact with cast iron would readily polarize in sea water and cause less galvanic corrosion than would copper.

In general, excessive galvanic corrosion does not take place when copper is coupled to its alloys or when different copper alloys are in contact with each other. The amount of galvanic corrosion on a less noble metal will depend on the relative areas of the two metals in contact and the potential or voltage existing between the two metals in a given environment. For example, large areas of copper or its alloys should not be coupled to small areas of reactive materials such as iron, zinc or aluminum in corrosive environments; on the other hand, the coupling of a copper or copper-alloy part having a small area relative to the area of the more reactive metal is usually quite safe.

A FURTHER LOOK

If corrosion products can form an adherent, non-porous coating on the metal, they will protect the metal from corrosion and the over-all protection will depend to a large extent on the solubility of the particular corrosion products in its environment.

Many of the corrosion products formed on copper and its alloys have low solubility and form adherent, relatively impervious films which help make these metals highly resistant to corrosion in many media. Because the extreme importance of films of corrosion products in protecting metal from rapid attack, make sure that any conditions which tend to remove these films are avoided. Otherwise, corrosion will be speeded to an unacceptable rate, and product life can be critically reduced.

REFERENCE:

Corrosion Resistance of Copper and Copper Alloys published by The American Brass Company, Waterbury 20, Connecticut.

cross-reference charts for . . .

From: Standard Sheet

DIE-CASTING ALLOYS

For zinc, aluminum, magnesium, and copper alloys.

The charts below provide a means of readily identifying the commercial alloy designation of a die casting from the alloy designation appearing in Government or other standard specifications.

REFERENCE:

Alloy Cross Reverence Charts, ADCI-MI-55T, published by American Die Casting Institute, Inc, 366 Madison Ave, New York 17, NY.

Zinc Base

Commercial Designation			Al 4%
Nominal Composition			
Symbol	Specifying Organization	General Spec. No.	Designation Used in Specifications
ASTM	American Society for Testing Materials	B86	AC41B
SAE	Society of Automotive Engineers	.....	903 925
FED	Federal Specifications	QQZ363	A B
AMS	Aeronautical Material Spec.	4803	

Aluminum Base

Commercial Designation			13*	380*	360*	218	39-11	43
Nominal Composition			Si 12%	Cu 3.5% Si 9.0%	Mg 0.5% Si 9.5%	Mg 8%	Cu 3.8% Si 11%	Si 5%
Symbol	Specifying Organization	General Spec. No.	Designations Used in Specifications					
ASTM	Amer. Soc. for Testing Matls.	B-85	S12A S12B	SC84A SC84B	SG100A SG100B	G8A	SC114A	S5C
SAE	Society of Automotive Engineers	.....	305	306 308	309		303	304
FED	Federal Specifications	QQA-591a-1	Comp No. 1 Comp No. 2	Comp No. 10 Comp No. 11	Comp No. 12 Comp No. 12a	Comp No. 7	.....	Comp No. 3
MIL	Military Specifications	MIL-A-15153a	Class 1	Class 10	Class 9	Class 7	.....	Class 3
AMS	Aeronautical Material Spec.	.....	4292	4291A-2	4290E	.....	.....	.....
AF	Air Force	MIL-A-8294	Comp No. 1	.....	Comp No. 2	.....	.....	.....

* These alloys available in two grades with different iron analysis levels. The lower iron grades are commercially designated 13x, A380 and A360.

Magnesium Base

Commercial Designation			AZ91A	AZ91B
Nominal Composition			Al 9% Zn 0.7%	Al 9% Zn 0.7%
Symbol	Specifying Organization	General Spec. No.	Designation Used in Specifications	
ASTM	American Society for Testing Materials	B94	AZ91A	AZ91B
SAE	Society of Automotive Engineers	——	501	501A
FED	Federal Specifications	QQ-M-38	——	——
AMS	Aeronautical Material Specs	4490D	——	——

Copper Base

Commercial Designation	Z30A	ZS331A	ZS144A
Nominal Compos.	Cu 60%	Cu 65% Si 1%	Cu 81% Si 4%
General Spec. No.	Designation Used in Specifications		
B-176 (ASTM)	Z30A	ZS331A	ZS144A
——	——	——	——
——	——	——	——
——	——	——	——

From: Metal Progress

Austenitic "Cold Working" for ULTRA-STRENGTH STEEL

Need for materials with higher strength-to-weight ratio has motivated the search for new heat treating processes for steels. Key to a new technique is plastic deformation within a certain temperature range, then quenching.

D. J. SCHMATZ
J. C. SHYNE
V. F. ZACKAY
Scientific Laboratory, Ford Motor Co.
Dearborn, Mich.

Steel can be improved by austenitizing it, quenching it to the austenitic "bay" between pearlite and banite where it is plastically deformed, then quenching it to room temperature.

The decomposition of austenite to nonmartensitic products, is minimized by choosing steels with high hardenability, and limiting the temperature range for deformation to the austenitic bay from which the steel is quenched to martensite. Essential features are schematically illustrated in Fig. 1. Microstructure, degree of deformation, and carbon content are significant variables.

The nominal compositions of steels examined at the Ford Scientific Laboratory were 0.48% C (steel 48) and 0.63% C (steel 63), with 3 Cr, 1.5 Ni, 0.75 Mn, 0.5 Mo and 1.5 Si.

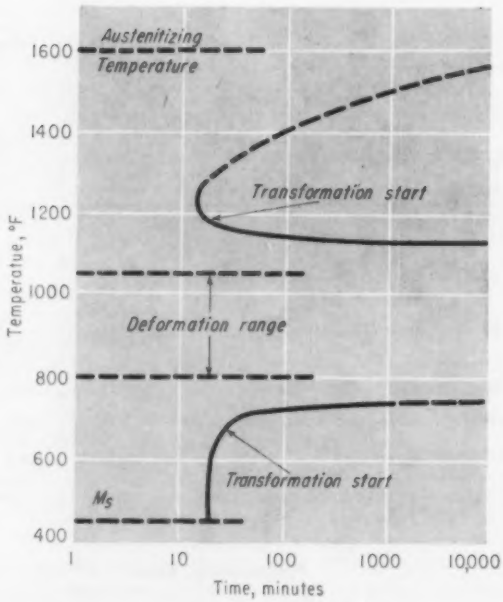
Present indications are that nonmartensitic transformation products are detrimental. The mechanical properties of steel 63 (deformed 90%) plotted against tempering temperature are shown in Fig. 2. One group of specimens was immediately oil quenched after deformation, while the others were air cooled to permit some nonmartensitic decomposition. The tensile and yield strengths of the steel containing nonmartensitic products were lower than its oil quenched counterpart. Ductility of both steels was found to be comparable.

Differences in microstructure suggest the reason for the superior strength of the oil quenched steel. It was essentially martensitic; however, the air cooled structure of steel 63, shown in Fig. 3, contained extensive nonmartensitic products on slip bands and on twin interfaces. These delineate the extent of metal flow, and their curved and intricate pattern indicates the absence of recrystallization in the severely deformed steels.

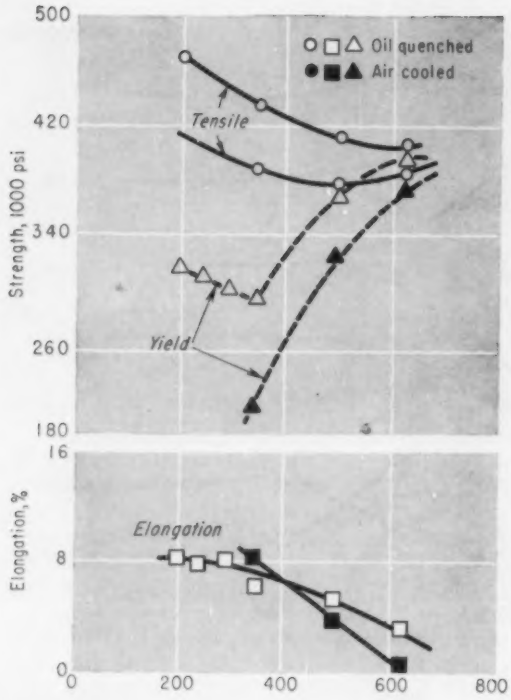
PROCESS REFINES MICROSTRUCTURE

Steels which have been Ausformed ("Ausform" is a Ford Motor Co. trademark) contains a refined microstructure. Electron photomicrographs of a carbon steel are shown in Fig. 4 (no austenitic deformation at left; deformed 93% at right). Both samples were oil quenched and tempered at 400°F for 1 hour. The largest martensite plate shown in the electron micrograph of the deformed steel is 1½ microns long. Martensite plates in the same steel, undeformed, measured about 3½ microns.

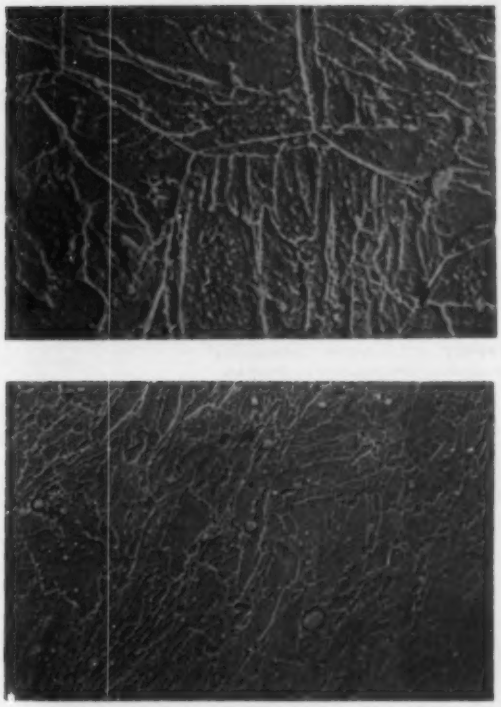
A relationship exists between the yield and fracture stresses and the size and distribution of microconstituent



1—TEMPERATURE-TRANSFORMATION-TIME DIAGRAM for steel showing features of ausforming—austenitizing and quenching to the metastable austenic zone where the steel is deformed.



2—EFFECT of nonmartensitic decomposition products on ausformed steel 63 (3 Cr, 1.5 Ni, 0.75 Mn, 0.5 Mo, 1.5 Si, 0.63 C), 90% deformed. The air cooled steel contained some ferrite-carbide aggregates; the oil quenched steel was martensitic.



4—ELECTRON MICROS of a 0.40% C steel. Left—Oil quenched from the austenitizing temperature and tempered 1 hr. at 400° F. Right—Ausformed (93% reduction) and tempered for 1 hr. at 400° F. Deformation has refined the structure. 15,000 X

3—PHOTOMICROGRAPH OF STEEL 63 (0.63% C) deformed 90% in the metastable austenitic condition and air cooled to permit formation of nonmartensitic products. 2000 X

in Ausformed steels. The microconstituent size is dependent in turn upon the prior austenite grain size and the degree of deformation.

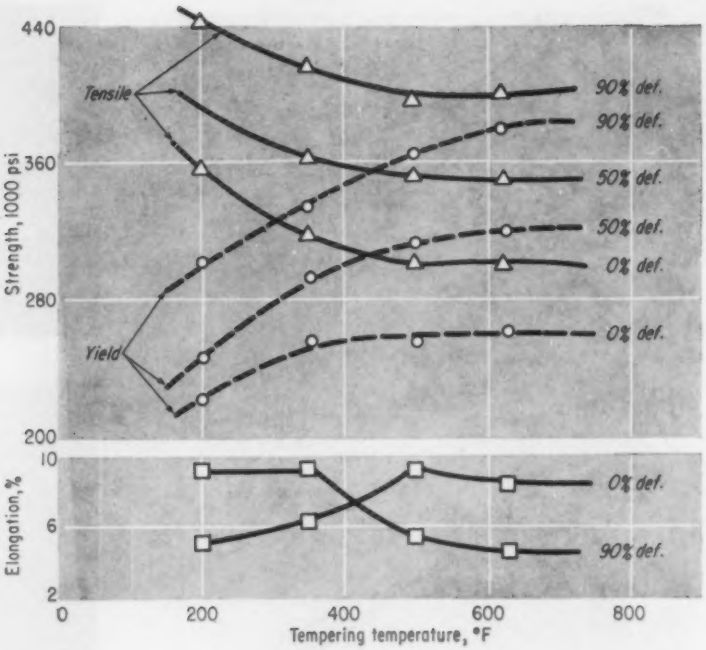
AUSTENITIC DEFORMATION INCREASES STRENGTH

Preliminary observations show that a critical amount of deformation is required for a significant increase in mechanical properties. Since large amounts of deformation are necessary for significant improvement in properties, and nonmartensitic products should be avoided, both deformation temperature and composition are critical. Optimum properties are obtained only by deforming in the temperature range of an austenitic bay. The extent of the austenitic bay is determined by the steel composition.

Steel 48 was deformed 0, 50 and 90% and oil quenched. Its yield and tensile strength and elongation are shown as functions of tempering temperature in Fig. 5. Large increases in both the yield and tensile strength occurred after both 50 and 90% reduction. The data for the 0 and 50% deformations were taken from specimens ¼ in. in diameter; however, the smaller finished bar of the 90% deformed material necessitated use of a specimen with a reduced section ⅛ in. in diameter. For this reason, the comparative elongation values should be regarded as qualitative. In general, best ductility was obtained at a low tempering temperature and high rate of deformation.

INTERSTITIAL CARBON IMPORTANT

Hardness and strength of martensite are known to be functions of the interstitial carbon content. The effects of carbon on the mechanical properties of steels 48 and 63 deformed 90% are illustrated in Fig. 6. The higher-carbon steel exhibited a greater strength over the complete tempering range. An ultimate tensile strength of 464,000 psi was observed for this steel after a 212° F temper. Yield



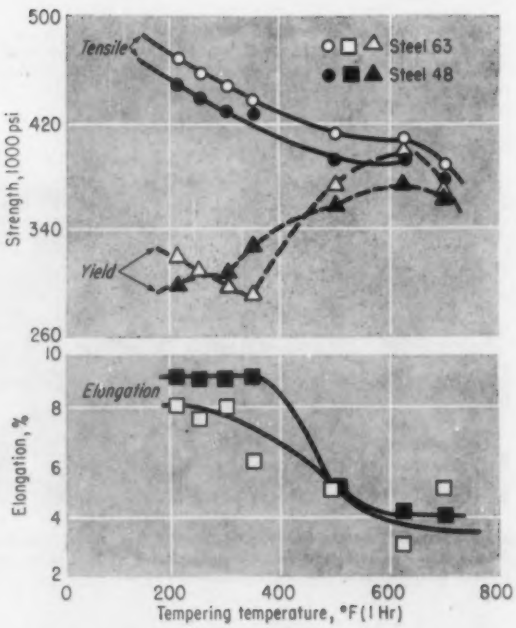
5—EFFECT of austenitic deformation and tempering temperature on mechanical properties of Steel 48 (3 Cr, 1.5 Ni, 0.75 Mn, 0.5 Mo, 1.5 Si, 0.48 C).

Historical

A decade ago, martensitic steel of S.A.E. 4340 type, oil quenched and tempered at 900F to a tensile strength of about 200,000 psi, was acceptable to the aircraft industry. The high tempering temperature was used to obtain specified elongation and impact toughness. Since then, the development of ultra-high-strength steels has been based on tempering temperatures below the so-called "500F."

A promising hardening technique was suggested by the Dutch scientists E. M. H. Lips and H. Van Zuilen. They reported unusually high tensile strength for a steel of high hardenability which was heat treated to a metastable austenitic condition, severely deformed between its recrystallization and martensitic transformation temperatures, and then transformed by cooling to room temperature.

Work at the Ford Scientific Laboratory has confirmed the feasibility of this sort of thermal-mechanical processing.



6—EFFECT OF CARBON on tempered steels which were deformed 90% while in the metastable austenitic condition.

strength rose sharply and uniformly above 350° F to about 400,000 psi after tempering at 600° F.

The elongation of steel 48 was generally greater than that of steel 63. This trend in rising strength and falling ductility with increasing carbon content was similar to that observed in conventionally heat treated martensitic steels.

REFERENCE:

Austenitic "Cold Working" for Ultra High Strength by D. J. Schmatz, J. C. Shyne and V. F. Zackay, Scientific Laboratory, Ford Motor Co, Dearborn, Michigan. Published in Metal Progress, Sept 1959, p. 66.

From: Electronics

for high temperatures these . . .

METALS for MAGNETS

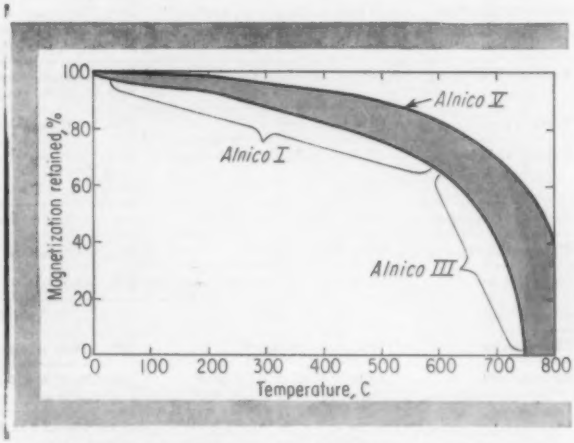
Magnetic materials with high Curie points and satisfactory metallurgical properties retain enough magnetization for use at high temperatures.

Permanent magnets able to retain a substantial portion of their magnetic properties at 500 C are needed in electronic components expected to operate in a nuclear environment. Within 5 to 10 years, new military aircraft and missiles will have temperatures over 500 C throughout most of the aircraft.

Components which require permanent magnets and which are likely to feel the effects of this advance in operating temperature include tranducers, traveling-wave tubes, magnetrons plus servo components and other small motors.

Investigations by Armour Research Foundation and Stanford Research Institute on temperature effects on typical permanent magnetic materials are summarized in Table I and Fig. 1. The data are also useful in designing below and above 500 C.

Design considerations—The Alnicos produced by several manufacturers are generally considered usable at 500 C. Except for Alnico III and the steels, however, the materials contain cobalt. The fact that cobalt will become radioactive in a nuclear environment should be considered in overall system design.



1. . MAGNETIC REMANENCE plotted against temperature.

Table I—Properties of 12 Permanent Magnet Materials

Alloy	Residual Flux Density (Gauss)	Coercive Force Oresteds	Max. Energy Product (BH)max	Gauss at (BH)max	Curie Temp (C)	Permanent Change (C)	Magnetic Losses at 500 C
Alnico I	7100	400	1,300,000	4000	870	535	Retain 75% (Alnico I) to 90% (Alnico V) of magnetization
Alnico II	7500	560	1,600,000	4600	800	535	
Alnico III	7000	470	1,350,000	4500	725	480	
Alnico IV	5500	730	1,250,000	3100	880	535	(BH)max and coercive force decrease 10–20%
Alnico V	12,700	650	5,500,000	10,400	880	535	
Alnico VI	10,100	750	3,800,000	7000	880	535	
Alnico VII	7000	1050	2,500,000	3700	870	535	Alnico V and VI usable to 700 C with 20% loss
Alnico XII	6100	1000	1,650,000	3200	...	480	
Indalloy	9000	240	9,000,000	....	...	...	Degrades but usable
Remalloy	10,000	230	1,100,000	6900	900	...	10–20% loss of remanence
Carbon steel	10,000	50	200,000	6200	770	...	May be used, but loses remanence
Tungsten steel	10,300	70	300,000	6800	760	...	

Loss of remanence may be compensated for by overdesign or by preaging the material at the operating temperature to offset irreversible magnetic changes due to temperature rise. Coefficients of thermal expansion for these materials are similar. The Alnicos being hard and brittle, are cast and finished by such methods as grinding, while the steels are ductile and machinable.

REFERENCE:
Hard Magnets for 500 C by George Sideris, Associate Editor, Electronics. Published in Electronics, Jan 9, 1959, p. 63.

chemical resistance of . . .

From: Laboratory Report

ZIRCONIUM, TITANIUM, TANTALUM and 316-STAINLESS STEEL

Tabulated findings include solution concentration in per cent, temperatures in degrees F, and resistance to attack graded as follows: Excellent—less than 0.0005 in. penetration per year; good—0.0005 to 0.005 in. per year; fair—0.005 to 0.010 in. per year; poor—more than 0.010 in. per year. **This table** was specially revised for PE.

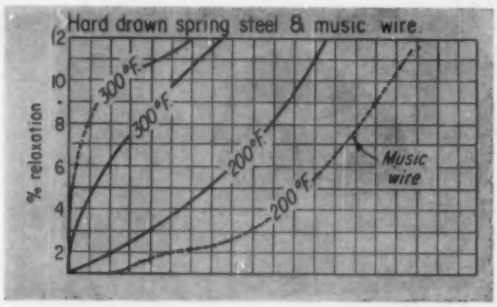
REFERENCE:
Titanium Metallurgical Laboratory Report #57, Battelle Memorial Institute, Columbus, Ohio.

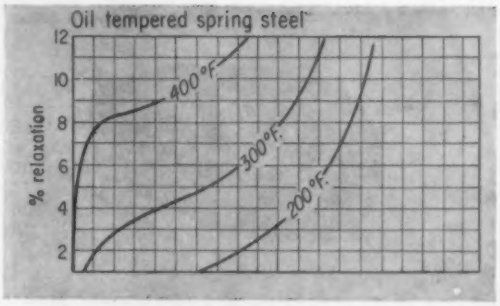
	ZIRCONIUM	TITANIUM	TANTALUM	STAINLESS STEEL TYPE 316
Acetic Acid	5 to 99.5%, 140 to 212 F, excellent	5 to 95.5%, boiling, excellent 5,10%, 68F, excellent	All %, 68 to 735 F, excellent	5% to glacial, 95 to 390 F, good
Aluminum Chloride	20 to 30%, 75 to 212 F, excellent	40%, 250 F, poor 10%, 95 to 212 F, excellent 25%, 140 F, excellent		
Ammonium Hydroxide	28%, 75 to 212 F, excellent	28%, room temp., excellent 2000 psi, 100%, 104 F, excellent		All %, good
Aqua Regia	65 to 140 F, poor	65 to 140 F, excellent	65 to 140 F, excellent	
Calcium Chloride	20, 30, 50%; 68, 120, 313 F, excellent	62%, 310 F, erratic 10 to 25%, 95, 121 F, excellent 40 to 55%, to 235 F, excellent	62%, 310 F, excellent	5% to saturated, 95 to 212 F, poor
Carbon Tetrachloride	100%; 75 to 120 F, excellent	1 to 99%, boiling, excellent		Room temp., good
Chlorine Saturated H_2O	Room temp., excellent	Room temp., excellent		95 to 212 F, poor
Chromic Acid	10, 20, 30%; 68, 120, 212 F, excellent	10%, boiling, good	40%, 140F, excellent	10 to 50%, 95, 212 F, fair to poor
Cupric Chloride	1 to 25%, 95 F, poor	1 to 15%, 95 F, excellent		1 to 5%, 70 F to boiling, poor
Ethyl Alcohol	95%, boiling, excellent	95%, boiling, excellent		
Ferric Chloride	2.5 to 30%, 65 to 212 F, poor	1 to 20%, 65 to 212 F, excellent	5 to 30%, 65 F to boiling, excellent	1 to 5%, 70 F to boiling, poor
Formic Acid	90% 68, 120, 212 F boiling, excellent	aerated, excellent; non aerated, poor 25 to 90% 95 F to boiling, good to poor	90%, 212 F, excellent	5%, 160 F, fair to poor
H_2O Saturated, Chlorine	Room temp, poor	Room temp., excellent	To 200 C, excellent	
Hydrochloric Acid	Dilute—excellent, all temps, concentrated at room—excellent concentrated at boiling—poor	5% to Concentrated, 95 to 212 F, poor 2%, 105 F, good	19% to concentrated, 65 to 212 F, excellent	Dry, moist, 68 F, poor
Hydrogen Peroxide	10%, 120 F, excellent	Room temp. to 30%, CP, poor, ACS, excellent Alloy MST 821, 90%, 160 F, good		
Lactic Acid	5 to 85%, boiling, excellent	85%, 95 F to boiling, excellent		5, 10%, 95 F to boiling, poor
Mercuric Chloride	1% to saturated, 95 to 212 F, excellent	1% to saturated, 95 to 212 F, excellent	Saturated at 212 F, excellent	0.5% to 2%, 70 F to boiling, poor
Mono-Chloro Acetic	100% boiling, excellent	100%, boiling, excellent		
Nitric Acid	10% to concentrated, 65 to 212 F, excellent	5% to concentrated, 95 to 212 F, good	33 to 99%, to 250 F, excellent	Dilute, excellent; poor in concentrated, at boiling
Oxalic Acid	1 to 25%, 212 F, excellent	1 to 25%, 95, 212 F, poor 0.5 to 10% aerated, 95 F, excellent	Saturated, 75 to 205 F excellent	10 to 25%, 70 F to boiling, poor
Phosphoric Acid	10 to 85%, 75 to 212 F, excellent to fair	1 to 85%, 65 to 212 F, excellent in dilute concentration at room-otherwise poor	85%, 290 to 410 F, excellent	10 to 85%, 68 F boiling, poor
Sodium Chloride	3%, 95 F, excellent	3%, 95 F, excellent	To 100%, 75 to 212 F, excellent	5%, 68 F, good
Sodium Hydroxide	10, 50%; 75 to 212 F, excellent	10, 40%, 175 F to boiling good	5, 40%, 212, 230 F, dilute-excellent, 40%—poor	All %, 175 to 600 F, excellent except in dilute boiling
Sulfuric Acid	10 to 96%; 65 to 212 F, excellent in dilute, poor in hot concentration	5 to 65%, 65 to 95 F, dilute—good, concentrated—poor	20% to concentrated, 85 to 570 F, excellent	25% to concentrated, good at 68 F; poor at high temp.
Tannic Acid	10%; room temp. to boiling, excellent	25%, 212 F, excellent		
Tartaric Acid	10, 25, 50%; 68, 120 F to boiling, excellent	10, 50%, 212 F, excellent		

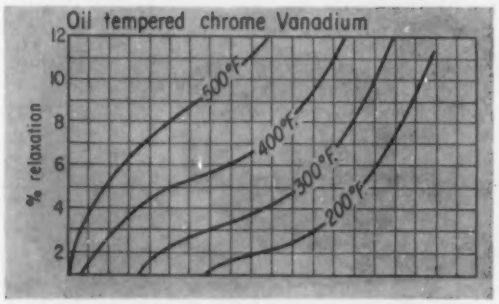
Spring Material at High Temperature

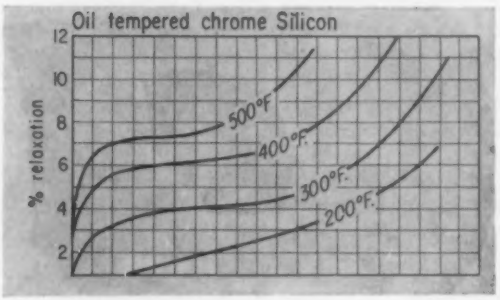
Relaxation charts of 10 frequently used helical-spring materials for various temperatures between 200F and 900F.

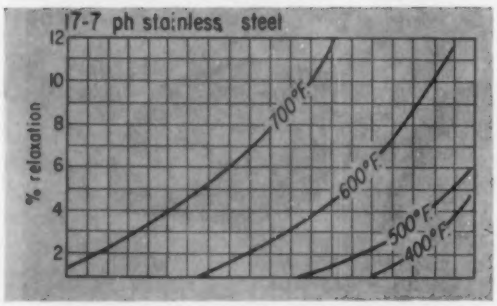
From: Company Bulletin

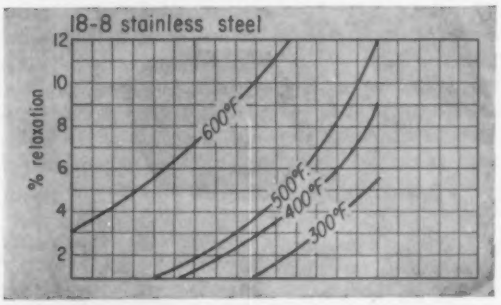


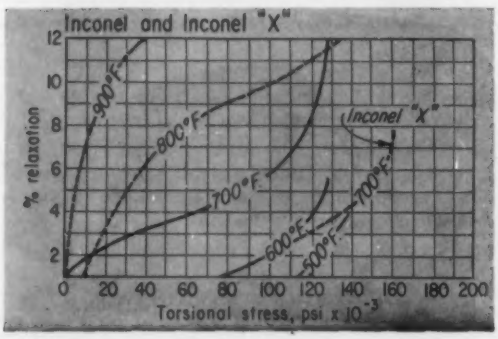


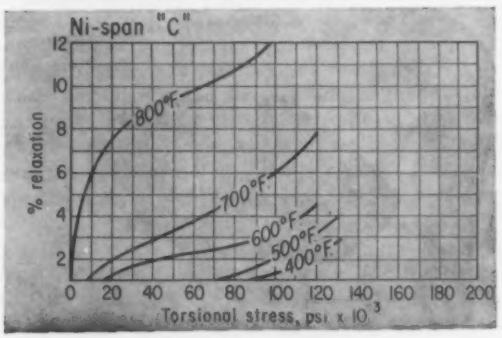












REFERENCE:
Effect of Elevated Temperatures on Helical Springs. Published in The Helix, Hunter Spring Co, Lansdale, Pa.

From: Literature survey

BERYLLIUM— what it can do and how it can be worked

Comparative features of the metal as a structural material together with recent information on how it is machined, formed and joined.

Beryllium with its lightness, high strength, stiffness and high specific heat could, although costly, solve many modern design problems. As an alloying material it has been popular for 30 years, while presently the pure metal finds jobs mainly in nuclear reactors and x-ray devices. But missile requirements are spurring efforts to overcome brittleness—the main obstacle to fabrication and more general use.

This is a rundown on the latest developments and engineering features that can make this metal more and more attractive as a structural design material.

ADVANTAGES

Lightness

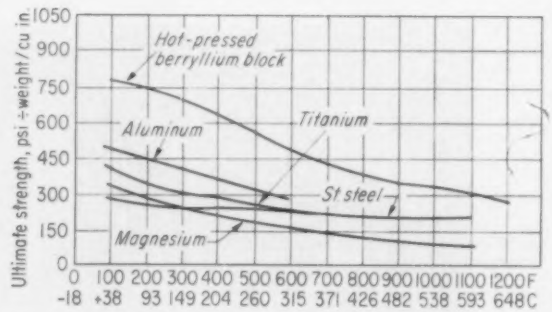
Lightness alone is reason enough for many uses such as low-inertia, high-speed, computer memory-discs, missile computer gears and other parts. Beryllium is almost as light as magnesium, only two-thirds as heavy as aluminum and less than one-fourth as heavy as iron. Example: Compared to stainless steel, which designers chose because of more knowledge about its performance, beryllium could have saved 20,000 lb if used as honeycomb foil in the B-70 bomber.

Strength and Rigidity

Add to lightness moderate strength (about equal to wrought aluminum) and high modulus of elasticity (1½ times steel) and you hit the heart of beryllium's appeal in structures—superior strength-weight and rigidity-weight ratios. With estimates of the cost to send one pound into orbit running around $30,000, even beryllium's high price is a bargain. Compared to other metals used in lightweight structures beryllium beats its nearest strength-weight rival, aluminum, by a ratio of 5 to 3 and its nearest elastic-modulus to weight ratio competitor, magnesium, by over 6 to 1.

High Temperatures

At 1200F beryllium has a higher strength-weight ratio than stainless steel. Magnesium melts at this temperature. While beryllium's 1285C melting point is not the 1800C necessary to classify the metal as refractory, it is high enough to allow the use of beryllium for leading edges of wings for high-speed aircraft and exhaust ducts of jet engines.



1. STRENGTH-WEIGHT RATIO of beryllium compared to other metals.

Specific Heat

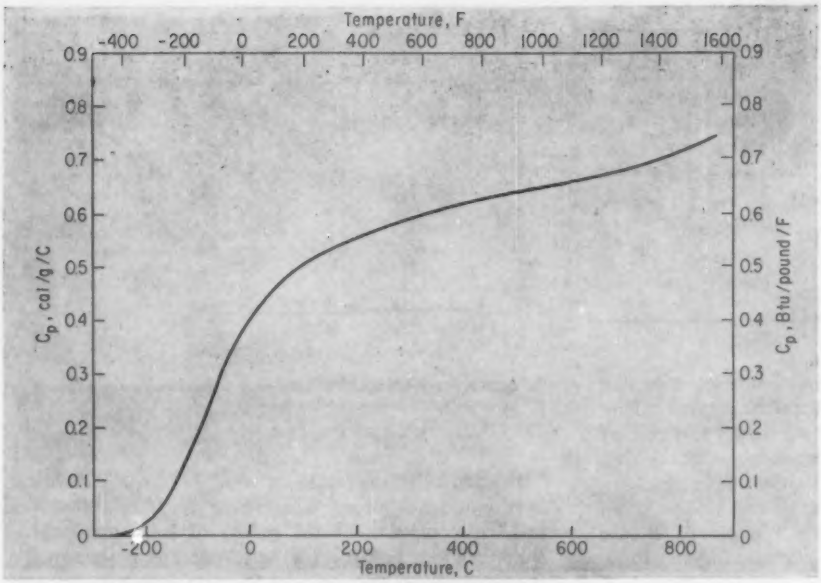
One of the biggest and most publicized beryllium forgings so far is the reentry heat sink for the Mercury space capsule. Beryllium is the choice because its specific heat is twice that of copper. For the same reason, aircraft brakes, that depend on one-shot heat capacity rather than fast dissipation, will use steel-plated beryllium discs. Impurities, especially beryllium oxide, lower heat capacity.

Electrical

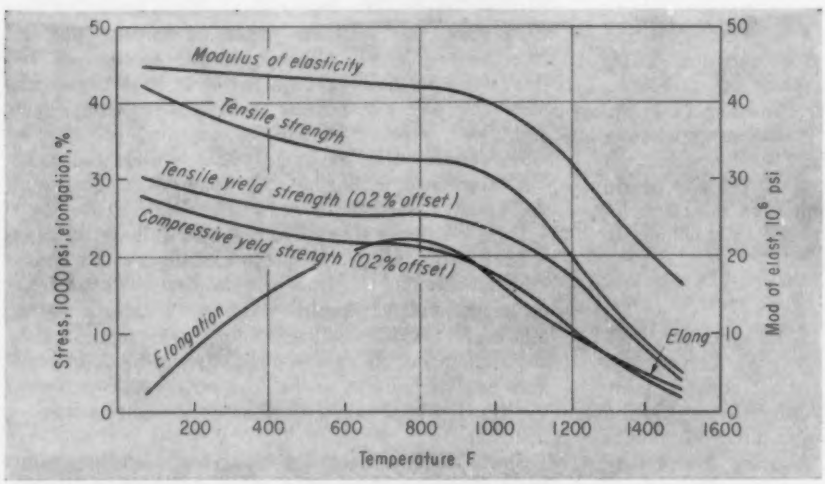
Airborne instrument cases depend on the heat capacity of beryllium to dampen out heat surges; the cases also take advantage of its good electrical conductivity by carrying current. If wire fabricating problems were solved, beryllium could be put to more general use as a good lightweight conductor.

Corrosion

Up to 800C beryllium resists corrosion, but over that it requires protection. This makes fabrication difficult since beryllium can often be worked only at high temperatures. Ions of impurities stimulate beryllium's corrosion in water. A beryllium oxide coating naturally formed, like aluminum



2. SPECIFIC HEAT of beryllium as a function of temperature.



3. CHANGE OF STRENGTH AND DUCTILITY of beryllium with temperature.

oxide on aluminum, shields the metal from corrosion in water. Organic acids form an automatically limiting protective coating on beryllium. To prevent galvanic corrosion of beryllium-magnesium, the metals must be separated by an epoxy resin coating, zinc chromate primer or other suitable, passive materials.

DISADVANTAGES

Cost

Beryllium is expensive from the time it comes out of the ground to the finished product. Beryllium is rare (0.0006% of the earth's crust) to begin with, and the ore is scarce in this country. In spite of government premium payments for US ore, domestic production for 1959 was less than 5% of our supply. A new field detector that depends on beryllium as a neutron source should help uncover ore deposits now hidden.

Since beryllium is a byproduct of feldspar or mica mining, crude hand sorting separates the ore, beryl ($3BeO \cdot Al_2O_3 \cdot 6SiO_2$). Flotation separation, which the US Bureau of Mines and at least one private company are developing, promises to allow mining presently worked deposits more efficiently and to tap the large quantities of low-grade ore in the Carolinas.

TABLE I — Physical Properties

Atomic number	4
Atomic weight	9.013
Specific gravity	1.85
Melting point, °C	1284 to 1300
Specific heat (0 to 100C), cal/g/°C	0.419 to 0.509
Coefficient of thermal expansion, (20 to 200C)	12.3 to 13.3 x 10^{-6}
Velocity of sound, m/sec	12,600
Electrical conductivity, % of Cu	38.9 to 43.1
Neutron cross-section, barns	0.009

The US Bureau of Mines calls beryllium ore reduction "the world's number one metallurgical headache." Not-so-simple techniques produce beryllium-copper master alloy without passing through a pure beryllium stage, but an even more complex method produces the pure metal.

Multi-tool machines convert ingots vacuum-cast from solid-lump beryllium into chips which plates crush into powder. The final raw material for machining and forming is usually a hot pressed billet.

Toxicity

Elaborate and expensive measures are required to protect workers' skins and lungs from beryllium dust and fumes. Vacuum systems remove chips and dust during machining; continuous filters clean plant air; washdowns prevent accumulations; special clothes and sometimes respirators provide direct protection; machinery enclosures keep dust and fumes from spreading. Beryllium dust can cause simple skin irritation, skin ulcers or even skin tumor. It is even possible for death to result from the effects of long-term exposure to beryllium dust that causes pulmonary edema—filling of the lungs with fluid.

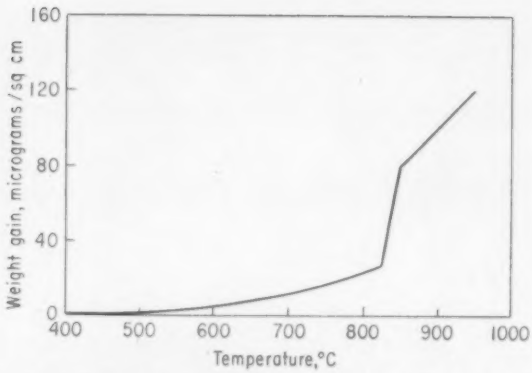
Brittleness

Impurities, especially beryllium oxide, aggravate beryllium's natural brittleness. When worked, beryllium is anisotropic—mechanical properties are not equal in every direction. Maximum ductility possible is 40% elongation in the direction of work, but in other directions elongation may be only a few percent. Alloying doesn't help much—almost all metals have low solid solubility in beryllium and form brittle intermetallic compounds with it. When copper is in solid solution with beryllium, it increases strength without changing ductility. Carbon, oxygen and silicon increase strength by forming dispersion-type alloys. Failing to increase ductility except by greater purity, most development aims at making it easier to live with brittleness.

FABRICATION

Machining

Fine grained, nonporous pressed powder machines easily, but cast beryllium is too brittle. Metal removal-rates must stay within the chip-exhausting system's limits. Economy forces maximum recovery of this expensive metal, so whenever possible avoid coolants, all of which contaminate beryllium.



4. OXIDATION OF BERYLLIUM in air. Samples were exposed for 60 mins at various temperatures.

Brittleness is the cause of most of the difficulties in beryllium machining. Chamfering or end pieces avoid end breakout, one of the results of brittleness. More troublesome is surface cracking brought on by two mechanisms, stick-slip friction and built-up edge on the tool. One research program gives the best combination of machining variables for good surface finish as follows: High tool rake angles, low depth of cut, light feed. Another study warns that extremely fine feeds generate heat and excessive tool wear. Although cutting speeds over 300 sfpm eliminate build-up edge, the strict requirement that metal chip and dust recovery be complete dictates a lower 250 sfpm. Following machining, chemical polishing removes surface cracks. Etching 0.002 in. is usually adequate.

Conventional milling at 150 sfpm rather than climb milling gives best tool life and surface finish.

During drilling, especially deep hole drilling, beryllium seizes tools frequently. A special toolholder with a spring-loaded tensioning device allows the drill to rotate freely on seizure and reduces drill breakage. Since there is no tool contact, spark discharge drilling gives good accuracy and edge definition. Otherwise a backup block of beryllium or steel prevents spalling around the hole exit when the drill breaks through. Recommended cutting speed is 100 sfpm.

Single-point tools and hot rolling best form threads, because brittle beryllium tends to spall. With dies, when small metal pieces crowd into the tool, threads tear and tools wear.

Beryllium is sensitive to cracking during grinding in a degree dependent upon the previous forming method. From most to least sensitive the order is: Extruded and rolled; extruded; cast. A special grinding wheel is available that holds cracking to a minimum.

Forming

The forging temperature range for beryllium is between 1550F and 2000F. Since beryllium oxidizes readily above 1500F, a mild steel casing must shield the metal. Either an extrusion or pressed powder is sealed into a sheath with end plates. Under a perforated end plate a graphite filter allows air to escape during heating but keeps beryllium in. A volatile hydrocarbon inside the can helps expel air.

TABLE II — Mechanical Properties of Beryllium

Property	Vacuum hot-pressed from powder	Hot extruded from hot-pressed powder
Ultimate tensile strength, psi	42,000	83,000
Tensile yield (0.2%), psi	32,100	39,500
Tensile elongation, %	2.3	16.0
Tensile modulus of elasticity, psi	44.4×10^6	41.4×10^6
Compression yield (0.2%), psi	24,600	38,000
Compression modulus, psi	44.2×10^6	41.8×10^6
Poisson's ratio	0.024	0.032
Ultimate shear strength, torsion, psi	38,900	81,000
Shear yield, torsion, psi	18,300	14,200
Shear modulus, torsion, psi	21.5×10^6	21.0×10^6
Twist to failure, deg	145	390
Ultimate shear strength, double shear, psi	36,800	61,300
Unnotched Charpy impact, ft-lb	0.8	4.1
Tensile impact, ft-lb	1.4	4.5
Hardness, Rockwell B	75–85	75–85

Standard hammers and dies forge the heated can which acid or peeling later strip of its steel skin.

Recent researchers claim when closed dies maintain continuous pressure pressmen can produce forgings that retain the same ductility and isotropy that strong aluminum alloy have.

Extruding requires a liquid glass coating around the billet to protect it from oxidation. Before extrusion the billet is heated to 1950F, then rolled in powdered glass which melts on the hot surface. The liquid glass also lubricates, helping the billet to enter the die without cracking. Engineers on one development program have extruded 15 ft channels from powdered metal billets which they hope to replace with cast ingots. The eventual goal is aircraft structural shapes 20 ft long. Biggest problem to overcome was extreme notch sensitivity. Cracking, galling and other surface deformations called rattlesnaking resulted when metallurgists first bare-extruded beryllium. Also solved is the anistropy of previous extrusions which proper grain orientation only in the direction of work caused. Kneading or forging before extrusion arranges the grains so that the final piece has just as good properties in all directions.

Sheet producing involved the same trouble. Rolling in one direction aligns grains to encourage cracking. Cross-rolling restores transverse ductility by controlling grain size and orientation. Sheet rolled in the hot range (1400F to 2100F) is more ductile, but that rolled in the warm range (850F to 1400F) is stronger. Hot rolled sheet starts out in the usual steel clad pressed billet which the developing cast ingot will also replace. Although beryllium exhibits peak ductility at 800F, two different sources report sheet bent between 1000F and 1200F is least likely to crack. Even cross-rolled sheet, when it is wide, is difficult to bend sharply.

Joining

Fusion welding meets with only the slightest success. During welding two things accentuate hot-short beryllium's brittleness. Large grains that form in the fusion zone, and rapid oxidation that no present flux prevents make beryllium susceptible to thermal cracks in or alongside the weld. One fabricator masters cracking only in 0.023 in. and 0.125 in. sheet by using the tungsten inert gas method in an argon or helium atmosphere.

Electron beam welding shows no results so far but enough promise to still warrant hope.

Pressure welding joins simple shapes at 5-10,000 psi pressure that differential expansion between graphite and beryllium generates. Heated to around 2000F the interface welds by recrystallization after 2½ hours.

Brazing is much more successful, yet not without its problems. A quickly formed oxide coating inhibits wetting, and intermetallic compounds that most brazing alloys form with beryllium are nonwetting. Temperatures just high enough to melt the filler and minimum heating times are best. Overlong heating time allows brazing material to spread away from the joint, and permits beryllium to diffuse to the brazing metal and create a brittle joint. This ready diffusion of beryllium into the braze metal limits the service temperature of a brazed part.

Furnace brazing under inert gas or hydrogen with pure silver or silver-copper eutectic makes a good joint which mild pressure improves. This method joins beryllium to beryllium and to some other metals.

Silver also works as cold wire feed to a tungsten inert gas arc. Good penetration into the joint and diffusion and alloying between beryllium and silver provide bonding strength as high or higher than the base metal.

A second braze welding variation, consummable electrode under helium shield, joins with aluminum-silicon alloy filler. In spite of porosity and lack of alloying between filler and beryllium, the welds are as strong as those that silver and tungsten arc make.

Notch sensitivity of beryllium requires that joints be radiused. Thermal stresses during welding and stress raising tool marks can initiate cracks along the joint, especially with the higher temperatures that tungsten arc produces.

The same fabricator who can fuse-weld beryllium sheet can resistance spotweld 0.012 in. through 0.125 in. sheet. Clean surfaces achieve best welds.

Solder beryllium by first applying a solution of copper chloride and turpentine and then reducing this coating by heat at 800F to obtain a copper deposit. From there on the usual soldering methods take cover.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(B-1) **Metal Melting**—Bulletin, 20 pp. Considers advantages of several special melting techniques such as vacuum induction melting, consummable electrode melting. Alleghany Ludlum Steel Corp, Oliver Bldg, Pittsburgh 22.

(B-2) **Design of Welded Aluminum Structures**—Brochure, 28 pp. Presents a design method which takes advantage of the strength of material in regions unaffected by heat of welding. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh.

(B-3) **Index of Literature About Aluminum**—Brochure, 30 pp. Lists Alcoa publications by product, process and industry. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh.

(B-4) **Aluminum Impact Extrusions**—Brochure, 34 pp. Describes manufacturing methods, metal properties, finishes, cladding and uses. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19.

(B-5) **Aluminum and Cryogenics**—Bulletin, 20 pp. Gives results of tests on aluminum at low temperatures. Shows some present uses. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19.

(B-6) **Aluminum Screw Machine Stock**—Bulletin, 120 pp. Tables give properties, composition and dimensions of stock. Sections give machining instructions, thread data and tables of general engineering interest. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19.

(B-7) **Aluminum Pig and Ingot**—Brochure, 12 pp. Tables show alloy composition and uses plus casting alloy mechanical and fabrication properties. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19.

(B-8) **Aluminum Welding Filler**—Brochure, 4 pp. Table rates filler when matched with parent alloys. Also charts information on brazing materials. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19.

(B-9) **Aluminum Mill Products**—Brochure, 12 pp. Gives alloy properties and manufacturing tolerances for products. Anaconda Aluminum Co, Box 1654, Louisville, Ky.

(B-10) **Free-Cutting Copper**—Bulletin, 6 pp. Discusses machining, properties and uses of four high-conductivity coppers. Anaconda American Brass Co, 414 Meadow St, Waterbury, Conn.

(B-11) **Magnesium and Titanium**—Brochure, 44 pp. Provides charts, curves, tables, discussions of physical, fabrication properties. Includes some comparisons with other metals. Brooks & Perkins, Inc, 1950 W Fort St, Detroit 16.

(B-12) **Beryllium and Other Alloys**—Bulletin, 10 pp. Tables give alloy properties and available forms. Alloys include copper-base, stainless steel and beryllium. The Brush Beryllium Co, 5209 Euclid Ave, Cleveland.

(B-13) **Beryllium Oxide**—Brochure, 12 pp. Lists properties, analysis and uses of this refractory, electrical and nuclear material. The Brush Beryllium Co, 5209 Euclid Ave, Cleveland, Ohio.

(B-14) **Vacuum Tube Brazing Alloys**—Bulletin, 4 pp. Lists alloys, brazing characteristics, critical impurity limits, vapor pressure of elements. Handy & Harman, 82 Fulton St, NYC 38.

(B-15) **Perforated Metal**—Brochure 8 pp. Illustrates patterns; gives sheet sizes and gages available. The Harrington & King Perforating Co, Inc, 5618 Fillmore St, Chicago 44.

(B-16) **Beryllium Copper Products**—Catalog, 20 pp. Explains material properties and considerations in design of spring devices. Describes springs, spring valves, others. Instrument Specialties Co, Inc, 244 Bergen Blvd, Little Falls, NJ.

(B-17) **Stainless Steel Wire**—Brochure, 24 pp. Tables show composition, properties and corrosion resistance of alloys. Also charts of general information about wire. Jones & Laughlin Steel Corp, Stainless & Strip Div, Box 4606, Detroit 34.

(B-18) **Stainless Steel Sheet and Strip**—Brochure, 34 pp. Charts and tables give physical properties and fabrication data plus corrosion resistance, dimensions and more. Jones & Laughlin Steel Corp, Stainless & Strip Div, Box 4606, Detroit 34.

(B-19) **Steel**—Bulletin, 20 pp. Pocket guide lists stainless, alloy and carbon steel analyses and mil specs. Also mill availability. Jones & Laughlin Steel Corp, Stainless & Strip Div, Box 4606, Detroit 34.

(B-20) **Cemented Carbides**—Brochure, 24 pp. Presents properties, applications, design suggestions for metals which include portions of tungsten, titanium, columbium, tantalum carbides. Kennametal, Inc, Lloyd Ave, Latrobe, Pa.

(B-21) **Powdered Metal Parts**—Catalog, 58 pp. Presents illustrations of sample applications, design data, machining information, composition and characteristics of alloys for small parts, gears and filters. Keystone Carbon Co, 1935 State St, St Marys, Pa.

(B-22) **Steel Bars**—Bulletin, 24 pp. Provides data on strength, machinability, uniformity, fatigue resistance, wear resistance and dimensional stability for bars produced by elevated temperature drawing process. La Salle Steel Co, Box 6800-A, Chicago.

(B-23) **Nonferrous Products**—Catalog, 20 pp. Furnishes table of properties of brass, bronze, copper and aluminum used to make standard shapes, plumbing parts and contract work. Mueller Brass Co, Port Huron, Mich.

(B-24) **Magnetic Shielding Alloys**—Catalog, 31 pp. Presents magnetic and physical properties, fabrication data on alloys in foil form or for fabricated shields. Magnetic Shield Div, Perfection Mica Co, 1322 N Ellston Ave, Chicago.

(B-25) **Cold Rolled Steel Strip**—Brochure, 16 pp. Contains samples of plain, precoated and pattern rolled strip. Design advantages discussed; applications illustrated. Thomas Strip Div, Pittsburgh Steel Co, Warren, Ohio.

(B-26) **Aluminum Extrusions**—Brochure, 12 pp. Lists properties and uses of available alloys. Briefly discusses basic types of extrusions and their qualities for different uses. Precision Extrusions, Inc, Green St, Bensenville, Ill.

(B-27) **Seamless Mechanical Steel Tubing**—Manual, 197 pp. Presents description of manufacturing processes, dimensional tolerances, chemical composition, physical properties, mill practices, trade customs, weight tables and tables of multiple lengths. Pittsburgh Steel Co, Grant Bldg, Pittsburgh 30.

(B-28) **Centrifugal Castings**—Brochure, 14 pp. Describes company capabilities. Castings up to 33 ft long or 54 in. diameter done in steels, nickel and copper alloys. Gives some metal analyses and properties. Sandusky Foundry & Machine Co, Sandusky, Ohio.

(B-29) Aluminum Mill Products—Catalog, 20 pp. Provides charts of mechanical properties, composition, uses, weights, sizes, shapes. Reynolds Metals Co, Richmond 18, Va.

(B-30) Aluminum Tooling Plate—Brochure, 6 pp. Discusses uses, advantages and specifications of wrought plate for tooling fixtures. Reynolds Metals Co, Richmond 18, Va.

(B-31) Metals for Centrifugal Castings—Brochure, 12 pp. Tables give metal composition, properties and specification number. Sandusky Foundry & Machine Co, Sandusky, Ohio.

(B-32) Platinum—Data folder, 45 pp. Describes solid and clad platinum and alloys in basic shapes and fabricated; transistor materials; plating solutions and anodes; gauze, electrical contacts and other products. Texas Instruments, Inc, Metals & Controls Div, 72 Forest St, Attleboro, Mass.

(B-33) Industrial Metals—Data folder, 28 pp. Presents beryllium, manganese, stellite and aluminum-iron alloy; precious and reactor metals. Texas Instruments, Inc, Metals & Controls Div, 72 Forest St, Attleboro, Mass.

(B-34) Clad Metals—Data folder, 53 pp. Provides data on composite metals for semiconductors, radio tubes, springs and high temperature uses. Texas Instruments, Inc, Metals & Controls Div, 72 Forest St, Attleboro, Mass.

(B-35) Thermostat Metal—Data Folder, 24 pp. Gives composition, properties, resistance welding characteristics of standard, nonmagnetic, and corrosion resistant types. Texas Instruments, Inc, Metals & Controls Div, 72 Forest St, Attleboro, Mass.

(B-36) Cobalt Alloy—Brochure, 4 pp. Describes composition, mechanical properties of cobalt-tungsten-chromium alloy for high temperature applications. WaiMet alloys Co, 5320 Oakman Blvd, Dearborn 2, Mich.

(B-37) High Temperature Alloys—Brochure, 4 pp. Provides properties and composition of cobalt base, high tungsten alloys with 20% chromium and small amounts of columbium. WaiMet Alloys Co, 5320 Oakman Blvd, Dearborn 2, Mich.

(B-38) Stainless Steel Castings—Brochure, 8 pp. Lists properties, compositions. Includes table for matching application to alloy. Waukesha Foundry Co, Lincoln Ave, Waukesha, Wisc.

(B-39) Copper-nickel Alloy—Brochure, 8 pp. Describes properties and compositions of metals designed for corrosion resistance and bearing qualities. Waukesha Foundry Co, Lincoln Ave, Waukesha, Wisc.

(B-40) Copper Tubing—Catalog, 8 pp. Describes sizes, alloys, lengths, tempers and properties of available range. Wolverine Tube, Div of Calumet & Hecla, Inc, 17200 Southfield Rd, Allen Park, Mich.

(B-41) Copper-zirconium Alloy—Brochure, 8 pp. Presents properties of a high conductivity alloy which retains strength at high temperatures. Amco Div, American Metal Climax, Inc, 1270 Ave of the Americas, NYC.

(B-42) Zirconium-copper Alloy—Brochure, 8 pp. Presents mechanical and physical properties of the alloy up to 500C. Amco Div, American Metal Climax, Inc, 1270 Ave of the Americas, NYC.

(B-43) Bronze Alloys—Brochure, 16 pp. Contains charts showing chemical composition and mechanical properties of alloys. Describes services and facilties. The American Crucible Products Co, 1317 Oberlin Ave, Lorain, Ohio.

(B-44) Welded Rings—Brochure, 20 pp. Outlines capabilities for making flash butt-welded rings of metals including titanium, aluminum, zirconium and steels. The American Welding & Mfg Co, Warren, Ohio.

(B-45) Aluminum Bronze—Bulletin, 4 pp. Provides physical properties, uses and forms of wear resistant alloy. Ampco Metal, Inc, Box 2004, Milwaukee.

(B-46) Steel Tubing—Bulletin, 12 pp. Supplies facts about welded steel tubing, plain or in semifinished components. Sizes ⅛ to ¾ in. OD. Avon Tube Div, Higbie Mfg Co, Fourth & Water Sts, Rochester, Mich.

(B-47) Textured Metals—Brochure, 6 pp. Illustrates some applications and surfaces of textured or perforated sheet and coils. Ardmore Products, Inc, 193 Aldene Rd, Roselle, NJ.

(B-48) Stainless Steels—Catalog, 24 pp. Describes precipitation-hardening stainless steel properties. Explains fabrication and gives sizes and forms available. Armco Steel Corp, Middletown, Ohio.

(B-49) Investment Castings—Brochure, 8 pp. Presents table of analyses and properties of alloys used. Show samples of work done. Austenal Co, Div of Howe Sound Co—Microcast Products, 224 E 39 St, NYC.

(B-50) Beryllium Copper Wrought Alloys—Catalog, 48 pp. Discusses available forms, properties, machining, joining pressworking, heat treating of four alloys. The Beryllium Corp, Box 1462, Reading, Pa.

(B-51) Electroplating and Electroforming—Brochure, 4 pp. Outlines capabilities for plating with precious metals and electroforming shapes which defy ordinary machining or casting. Bart Laboratories & Design, Inc, 135 Manchester Pl, Newark 4, NJ.

(B-52) Zinc-rich Paint—Brochure, 4 pp. Corrosion resistant zinc coating keeps rust from spreading. Gives corrosion test data and instructions for applying. Bart Laboratories & Design Co, 135 Manchester Pl, Newark 4, NJ.

(B-53) Aluminum-bronze Alloys—Bulletin, 16 pp. Provides tables of physical properties and typical uses where resistance to wear, corrosion and erosion are required. Ampco Metal, Inc, 1784 S 38 St, Milwaukee, Wisc.

(B-54) Beryllium—Brochure, 8 pp. Describes nuclear, aircraft structural and other uses. Includes tables of properties and composition. Describes available forms of the metal. The Beryllium Corp, Reading, Pa.

(B-55) Tool Steels—Booklet, 24 pp. Discusses advantages, typical analysis, heat treatment, uses, characteristics, how to work special grades. Bethlehem Steel Co, Bethlehem, Pa.

(B-56) Drop Forgings—Brochure, 16 pp. Describes forging, heat treating, machining, inspection facilities. The Billings & Spencer Co, 1 Laurel St, Hartford, Conn.

(B-57) Steel Tubing—Brochure, 11 pp. Describes manufacturing process, properties, applications of copper coated steel, double-walled tubing. Bundy Tubing Co, 8109 E Jefferson, Detroit 14.

(B-58) Zirconium—Two bulletins, 10 pp. Gives properties, available forms and uses of zirconium in atomic reactors and chemical process industry. Carborundum Metals Co, Akron, NY.

(B-59) Stainless Steel—Brochure, 12 pp. Shows company capabilities for converting stainless steel into sheet and forgings. Operations include rough machining and cutting to size. G O Carlson, Inc, Thorndale, Pa.

(B-60) Cold Formed Shapes—Catalog, 24 pp. Shows shapes and variable dimensions which can be made from blanks up to 72 in. OD using stock dies. Commercial Shearing & Stamping Co, 1775 Logan Ave, Youngstown, Ohio.

(B-61) Powdered Metal Parts—Brochure, 6 pp. Describes process, typical parts, advantages, design considerations, facilities. Compacted Metals Corp, 99 Greenwood Ave, Waukegan, Ill.

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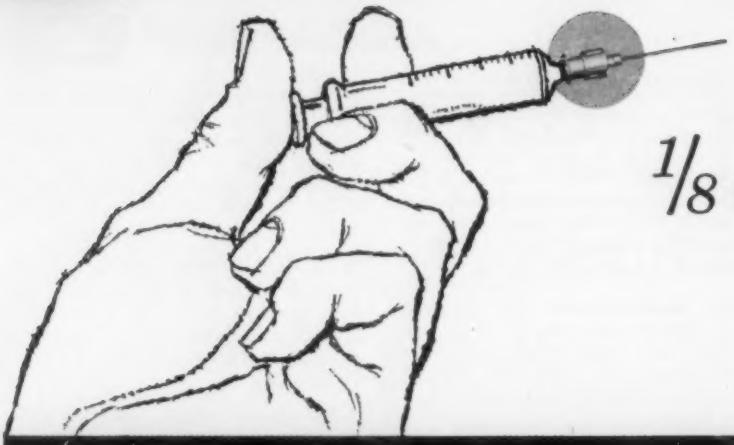


1/8 inch or 80 feet wide...

Roehr Products Co., Inc. disposable hypodermic needle. Hypodermic needle shown at top has corrosion-resistant aluminum hub. Aluminum is easy to machine; a pound provides 3 times more parts than a pound of brass.

Milwaukee Crane Division overhead crane. This aluminum crane saves 35 tons in total weight; requires lighter supporting members. Lifting capacity is increased, and maintenance is at a minimum.

REYNOLDS ALUMINUM

Aluminum

takes on more shapes to improve more products, reduce more costs

Every year, more products and parts are being designed or redesigned in aluminum—aluminum, because it improves product performance and appearance, and because it often lowers costs as well.

Perhaps one of the most important advantages aluminum offers the designer today is its wide variety of basic forms and alloys. Tube, rod, wire, pipe, powders, bar stock, a multitude of extrusions, sheet, plate, coil, pre-painted sheet, and even foil. All these—and more—are available in a full range of dimension and alloys.

And aluminum is well suited to most fabricating operations—machining, drawing, extruding, bending, cutting, or stamping. Lightweight and easy to work, aluminum often reduces production time, labor, and tool wear.

Because aluminum is so light in weight, you get more metal per pound than with other common metals. Result: more parts per pound, lower cost per part. The aluminum hub of the disposable hypodermic needle on the opposite page is an example of this economy.

Light as aluminum is, it is stronger, pound for pound, than steel. Supporting members of large equipment and structures can often be reduced—as in the aluminum crane shown opposite—to cut the total cost of a project.

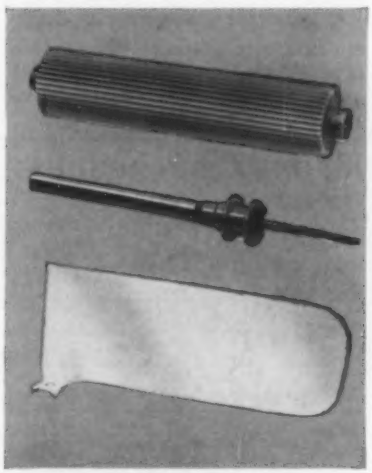
Corrosion-resistant and rustfree, aluminum serves longer with less maintenance in many products exposed to contaminating atmosphere.

Aluminum has also come into its own because of its advantageous electrical properties. Aluminum wire and cable, bus bar, electrical conduit and foil, with their high conductivity, strength, and light weight have opened new design horizons to the designer of electrical systems and products.

Whether your product is one-eighth inch or eighty feet wide, chances are Reynolds Aluminum can help you make it better, and help you reduce its total cost. For further information, technical advice and literature, write *Reynolds Aluminum, Box 2346-HN, Richmond 18, Virginia.*

The Pepsi-Cola Company—case. This carrying case, made for Pepsi-Cola Company with aluminum extrusions, is lightweight, good looking. It is durable, clean and sanitary because aluminum will not rust. And, its extremely long life is an important economic factor.

Southern Gravure Service, Inc., rotogravure printing cylinders. Cool running (because aluminum dissipates heat quickly and evenly), well-balanced aluminum rotogravure roll weighs one-third as much as non-aluminum roll. Shipping costs are reduced, longer press runs are possible, inks dry properly, and bearings last longer.



Whitin Machine Works textile machinery. Aluminum offers many advantages for textile machinery parts: economy, strength, and rigidity. Aluminum's light weight reduces machinery wear, it resists corrosion, warping and distortion.

Since World War II designers of air and space craft have made ever-increasing use of honeycomb in a great variety of structural and non-structural applications. Honeycomb can be made from almost any material available in continuous web or roll form, e.g., aluminum, glass fabric, cotton, stainless steel, paper, asbestos, titanium. In its cellular configuration, honeycomb is 97% air, 3% material.

Honeycomb has intrinsic qualities of high strength, light weight, high ratio of surface area to volume and other specific properties which depend upon the type of material used. These combinations of properties, which have given honeycomb wide application in air and space craft, offer to designers in industry generally unique opportunities in product design.

In the interest of advancing this knowledge of honeycomb, Hexcel, through its research and development staff (the industry's largest), has prepared this informational series. Should you desire additional technical information, please complete the information request form on this page. Your request will receive immediate attention.

INFORMATION REQUEST

Send to Hexcel Products Inc.
2332 Fourth Street, Berkeley 10, California

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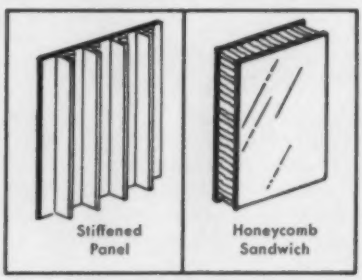
World leader in honeycomb

Executive offices: 2332 Fourth St., Berkeley, California. Plants: Oakland and Berkeley, California; Havre de Grace, Maryland. Sales Offices: Inglewood, California; Fort Worth, Texas; Long Island City, New York.

HONEYCOMB SANDWICH PANELS

Strength/Weight Ratio

Traditional design of flat panel structures to resist bending or column loading has been to use either thick plates or thin sheets stiffened with angle extrusions to form a more or less rigid panel. Where end use of panel requires a high stiffness-to-weight ratio or a superior strength-to-weight ratio, many designers have turned to the use of sandwich structure.



Sketch #1

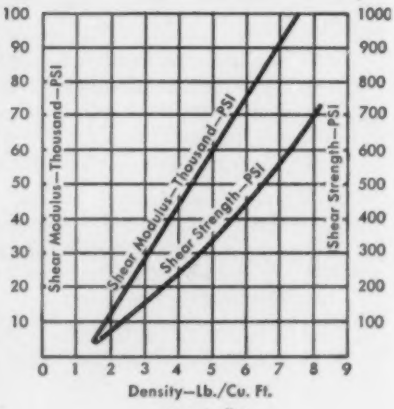
In a sandwich structure, the panel is made up of two faces with a light weight core material between them. In order to qualify as a structural sandwich, the core must be rigidly attached to the two faces. When these requirements are met, the resulting structure is capable of the highest strength-to-weight and rigidity-to-weight ratios presently obtainable by ordinary design methods.

Sandwich Structures:

A Design Approach

Sandwich structures are really a method of design approach rather than a single material. It is possible to design structures precisely tailored to fit the requirements at hand. Not only can the thickness and type of facing material be varied, but the thickness and density of the core material is subject to the designer's choice.

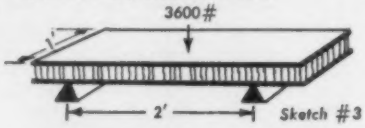
In the two curves shown, shear strength and shear modulus are given for Hexcel aluminum honeycomb in densities ranging from two to eight pounds per cubic foot. The strengths these core materials develop compare favorably with the strength of much heavier cores of plastic foam, wood fibers or other less efficient materials.



Sketch #2

Bending Loads

Bending strength and the bending rigidity of sandwich panels are two primary reasons for their broad acceptance in the area of light weight structures. In comparing panels loaded as shown in the sketch below, it can be shown that honeycomb sandwich is by far the lightest of any usable structure.



Sketch #3

3600 LB. WEIGHT - - - - - 24" SPAN

Material	Deflection (in inches)	Weight (in pounds)
Honeycomb Sandwich	.058	7.79
Nested "I" Beams	.058	10.86
Steel Angles	.058	25.9
Aluminum Plate	.058	34.2
Magnesium Plate	.058	26.0
Steel Plate	.058	68.6
Glass Reinforced Plastic Laminate	.058	83.4

The list of weights and deflections in the above table gives a clear indication that honeycomb sandwich panels have broad areas of application.

Chromel-R—A modified 80-20 nickel-chromium alloy for use in potentiometers and precision wire wound resistors. Possesses resistivity of 800 ohms/cmf at 20° C., temperature coefficient controlled within 0 ± 10 ppm/°C., exceptional linearity and stability from —65° to +150° C.

Chromel-P/Alumel—The world's standard base metal thermocouple combination for measuring operating temperatures in laboratory and heat treat furnaces—jet engines, nuclear reactors. Accuracy is guaranteed to close specified limits over the entire range from —300° to +2300° F.

Chromel-A—The original 80-20 nickel-chromium resistance alloy that first made electric heating practical. Widely used in major appliances, industrial furnaces and many other devices requiring heating elements capable of operating up to 2150° F. under adverse conditions.

Alloy 815-R—A lower density, higher resistivity iron-chromium-aluminum resistor material that gives you 14% more ohms per pound. Noted for strength, ductility, resistance to wear and corrosion. Resistivity: 815 ohms/cmf at 20° C. Temp. Coeff.: 0 ± 10 ppm/° C. from — 65° to +150° C.

Chromel-P/Copel-XM—A basic thermo-electric alloy combination used primarily as thermopiles to actuate and control operating temperatures of domestic furnaces, hot water heaters, stoves, ranges and other types of heating equipment. Noted for accuracy and reliability in service.

Chromel-AA—A new modified 80-20 type nickel-chromium resistance alloy developed especially for use in controlled atmosphere furnaces. It is highly resistant to corrosion, carburization, oxidation and "green rot" over the entire range of operating temperatures up to 2150° F.

Copel—A 55-45 copper-nickel alloy for use in edge-wound resistors, rheostats, motor starters and many other types of devices where operating Temperatures do not exceed 1000° F. Has resistivity of 294 ohms/cmf at 68° F., low temperature coefficient and exceptional mechanical stability.

Hoskins Cunife—A new improved copper-nickel-iron ductile permanent magnet alloy. Possesses high coercive force and energy product values, greater uniformity. Readily stamped, machined or otherwise formed by conventional methods for economical production of close tolerance parts.

Chromel-C—A 60-16 nickel-chromium-iron alloy used primarily as heating elements in small domestic appliances and other devices that require high resistance in limited space for operating temperatures up to 1700° F. Also used as cold resistor alloy in current-temperature controls.

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HOSKINS Custom Quality ALLOYS

Chromel-D—A time proven low nickel heating element alloy developed for use in controlled atmosphere furnaces required to operate in the critical temperature range between 1500° and 1800° F. It is highly resistant to corrosion, possesses exceptional mechanical stability.

Alloys 815, 835 and 875—Three superior iron-chromium-aluminum resistance alloys for use at operating temperatures up to 2150°, 2250° and 2350° F. respectively. Suitable for certain types of appliances, industrial furnaces and kilns where proper supports can be provided.

DETAILED TECHNICAL DATA on these and other Hoskins Custom Quality Alloys are yours for the asking. Hoskins metallurgical research, development and customer engineering services are also available to help you solve special design and application problems. Write or call today!

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Developing and producing custom quality alloys is a specialty at Hoskins—and has been for over 50 years. Some, like Chromel-A, have been responsible for the birth and growth of entire industries. Others have made possible many technological advancements in the design and performance of countless different end-products.

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Republic's tube making know-how and fabricating facilities combined to solve a tough problem for the Kuhlman Electric Company, Birmingham, Michigan.

Kuhlman engineers wanted a material to meet the designs of the new Kuhlman "Quick-Grip" H.V. transformer bushing that would reduce radio noise without oil. They preferred the part supplied as a finished product.

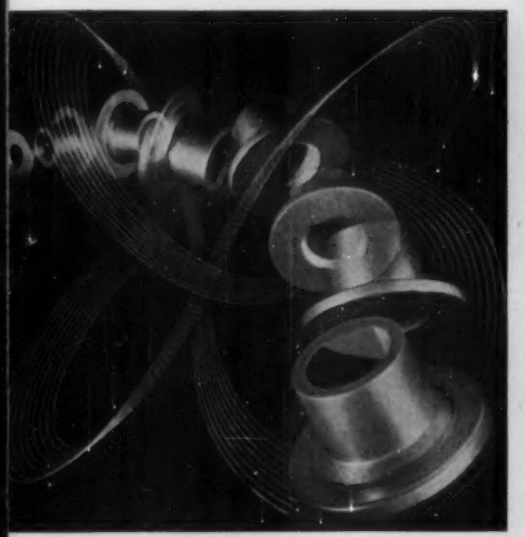
A bushing sleeve made of Republic ELECTRUNITE Carbon Steel Mechanical Tubing, 2⅜" O.D., 10-gage, was the answer. The sleeve is approximately 3" long and has a chamfer on one end. Holes are punched on circumference, and the other end of the tubing is expanded. Coarse threads are cut in the expanded metal on an automatic screw machine.

This is a typical example of the flexibilities in fabrication of ELECTRUNITE. And Republic's Steel and Tubes Division has the facilities, equipment, and "know-how" to fabricate all grades and types of ELECTRUNITE carbon and stainless steel tubing into whatever shapes your product requires.

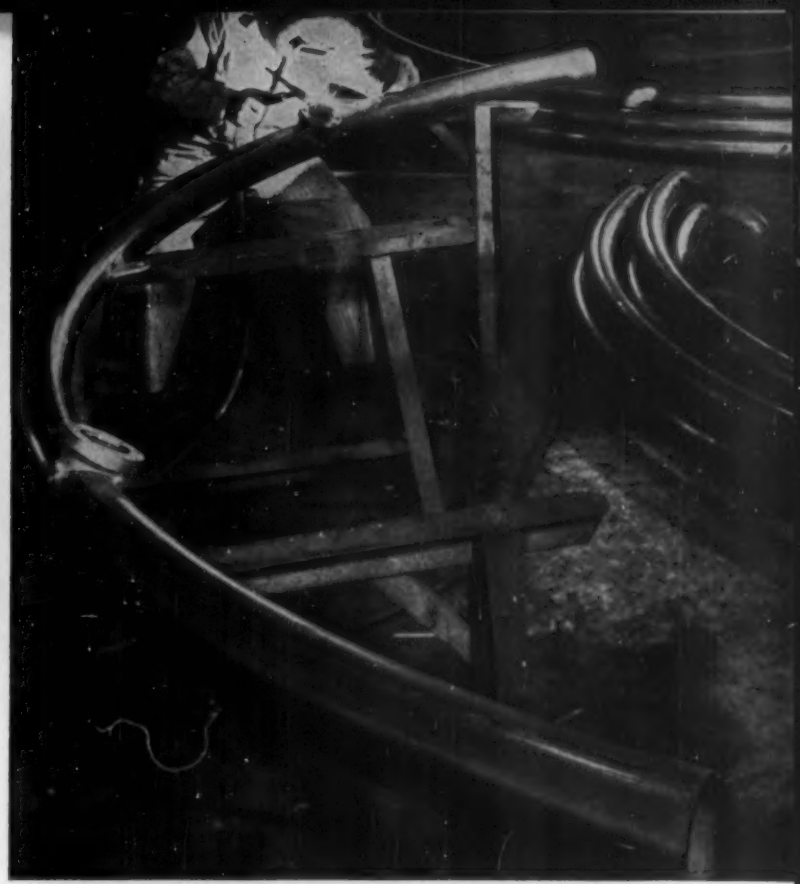
ELECTRUNITE is available in a wide range of sizes, gages, and wall thicknesses in both carbon and stainless steel. Call your Republic representative. Or, write direct. Use coupon below.

The Kuhlman "Quick Grip" H.V. sleeve, made of Republic ELECTRUNITE Mechanical Tubing, is a feature of the K-E Kuhlman Transformer, engineered and manufactured by the Kuhlman Electric Company, Birmingham, Michigan.

CIRCLE 80 ON READER SERVICE CARD



REPUBLIC HS6460 HIGH STRENGTH POWDER can be used to produce comparable strength structural parts at lower manufacturing costs than obtainable with copper infiltration. Additional production economies can be achieved because fewer operations will be required to obtain high density, higher strength parts. HS6460 is capable of minimum tensile strength of 60,000 psi at 6.4 density—100,000 psi after heat treatment.



REPUBLIC ELECTRUNITE STAINLESS STEEL TUBING, Type 304, 4½" O.D., was used to fabricate corona rings for a powerful East Coast Navy Radio Station. Despite the rather severe bend of the 15- and 20-foot rings, the fabricator reported no trouble whatsoever. The rings were made in three sections. ELECTRUNITE was bent to the correct radius. Three lugs were welded to each section. The ends were flared for the insertion of a plug used at the erection site to assemble the unit and suspend it from towers. ELECTRUNITE Stainless Steel Tubing and Pipe are available in most A.I.S.I. analyses from ⅜" O.D. to 5" O.D. Send for data.

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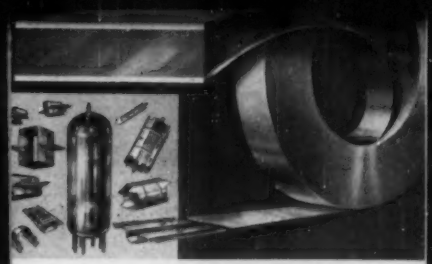

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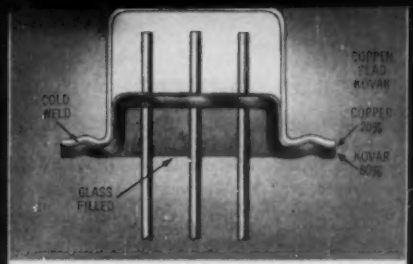

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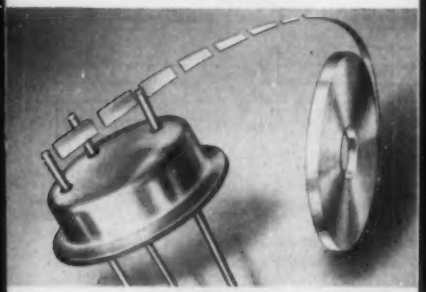

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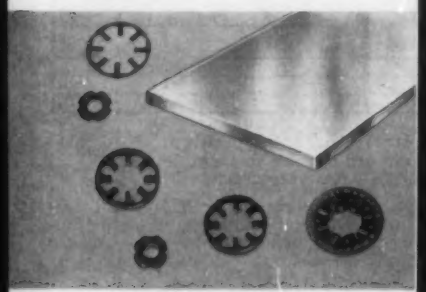

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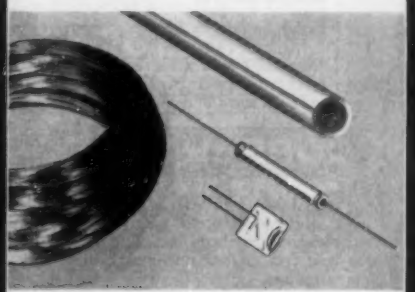
For magnetic applications requiring low core losses and high permeability at low flux densities in current and pulse transformers, relays, gyro mechanisms, servomechanisms, missile guidance systems, etc.



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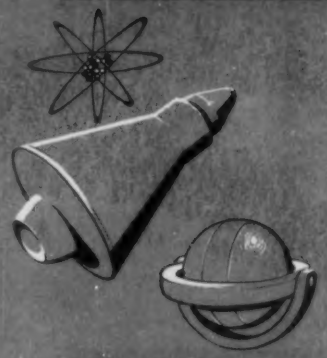

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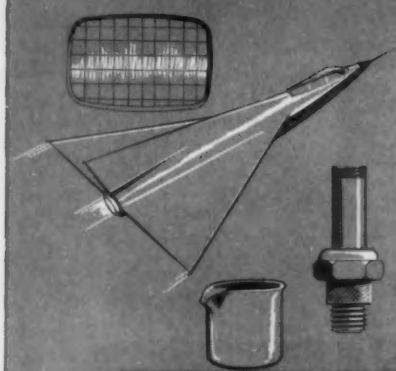
	BLOCK	SHEET	EXTRUSIONS
ULTIMATE TENSILE (psi)	40,000	75,000	90,000
TENSILE YIELD (psi)	30,000	55,000	65,000
ELONGATION (%)	1-4	5-10	7-15
YOUNGS MODULUS	44,000,000 psi		
SPECIFIC HEAT	0.46 BTU/lb./°F		
THERMAL CONDUCTIVITY	0.3 BTU/ft.²/Sec (°F/in.)⁻¹		
ELECTRICAL CONDUCTIVITY	40-45% I.A.C.S		
DENSITY	1.85 g./cc.		
MELTING POINT	2345°F		
REFLECTIVITY—WHITE LIGHT	55%		
NEUTRON SCATTERING CROSS SECTION	7 BARNS/ATOM		
NEUTRON ABSORPTION CROSS SECTION	0.01 BARNS/ATOM		

UOX® BERYLLIUM OXIDE

The sinterable oxide for high performance applications.

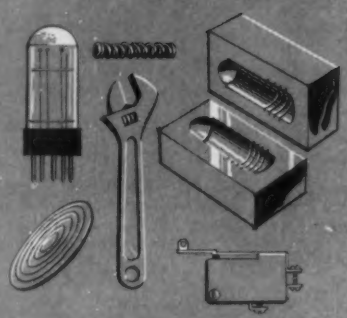


UOX, the high purity, sinterable ceramic oxide, is available as powder, crucibles, and special shapes fabricated to precision tolerances. Applications include nuclear moderators, reflectors and fuel matrices, heatsinks for aircraft and electronic devices, electronic tube components and metallurgical crucibles.

	ROOM TEMP.	2200°F.
COMPRESSIVE STRENGTH (psi)	114,000	20,000
TENSILE STRENGTH (psi)	18,000	4,000
MODULUS OF RUPTURE (psi)	35,000	14,000
MODULUS OF ELASTICITY (psi x 10⁶)	45	20
SPECIFIC HEAT (BTU/lb./°F.)	0.24	0.57
THERMAL CONDUCTIVITY (BTU/hr./ft.²/°F./ft.)	125	9.7
RESISTIVITY OF LOW DENSITY BeO (Ohm-cm. x 10⁶)	7000	4
SPECIFIC GRAVITY	3.008	
MELTING POINT (°F.)	4658	
COEFFICIENT OF EXPANSION (in/in/°F. x 10⁻⁶) R.T.-500°F.	4.4	
COEFFICIENT OF EXPANSION (in/in/°F. x 10⁻⁶) R.T.-2200°F.	6.2	
THERMAL SHOCK RESISTANCE	Excellent	
DIELECTRIC CONSTANT (10⁷ cps)	6.9	
LOSS FACTOR (10⁷ cps)	0.0004	

BERYLLIUM COPPER

High strength, good conductivity, corrosion and wear resistance, and excellent fatigue strength.



Available as casting alloy, master alloy, billets, forgings, bar, plate, and precision-rolled strip, these versatile alloys fill a wide range of uses including mechanical springs, electrical contacts, diaphragms, bellows, connectors, plastic mold cavities, non-sparking tools, switchgear, welding electrodes and wear surfaces.

TYPICAL MECHANICAL PROPERTIES OF BERYLLIUM COPPER PRECISION STRIP.

		BEFORE HEAT TREATMENT		AFTER HEAT TREATMENT		
Alloy	Temper	Tensile Strength psi	Elong. % in 2 in.	Tensile Strength psi	Elong. % in 2 in.	Elec. Cond. % IACS
25	Annealed	60- 75,000	35-60	165-190,000	4-10	22-25
	Hard	160-120,000	2- 8	190-215,000	1- 4	22-25
165	Annealed	60- 75,000	35-60	150-180,000	4-10	22-25
	Hard	160-120,000	2- 8	180-200,000	1- 4	22-25
10	Annealed	35- 55,000	20-35	100-110,000	8-12	48-55
	Hard	70- 85,000	5-10	110-125,000	5- 8	48-52
35	Annealed	35- 55,000	20-35	100-110,000	8-12	48-55
	Hard	70- 85,000	5-10	110-125,000	5- 8	48-52
25	XHM	Mill-hardened		170-185,000	3- 7	25-33
165	XHM	Mill-hardened		160-175,000	3- 7	25-33

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BERYLLIUM COMPOUNDS: Beryllium Fluoride, Hydroxide, Nitrate, Sulfate.
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PRECISION-ROLLED STRIP: Phosphor-Bronze, Brass, Nickel-Silver, Stainless Steel,
ALLOYS: Beryllium-Aluminum, Beryllium-Nickel, Special Alloys.

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- ☐ Wall Chart
- ☐ "Effect of copper, abnormally heavy drafts, furnace treatment, and die practice on STRESSPROOF Steel Bars."
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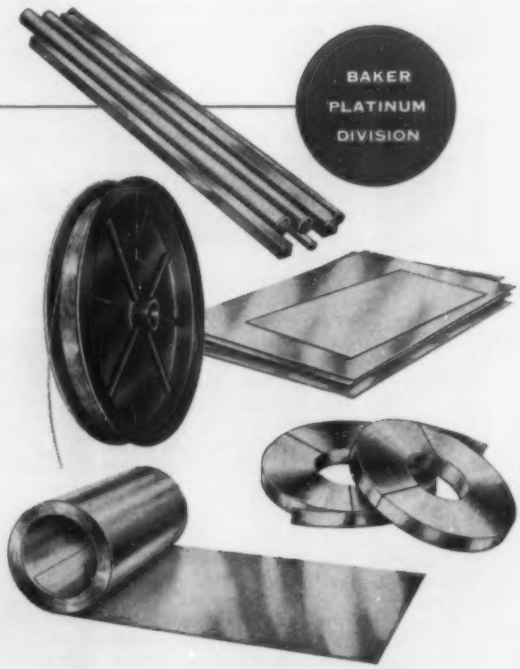

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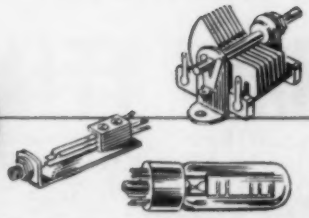

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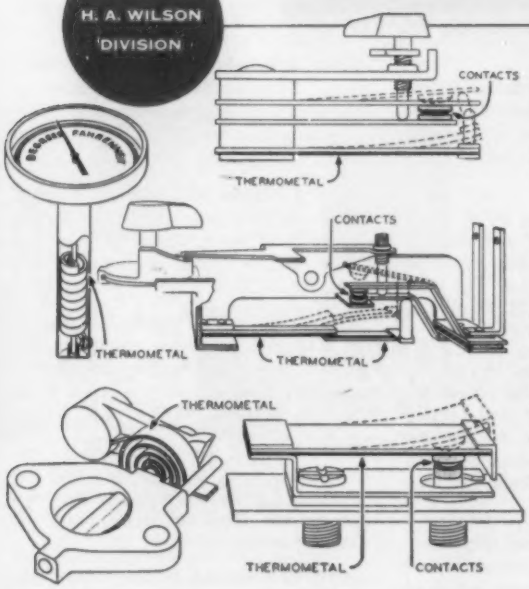

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(B-65) **Strip Steel**—Brochure, 14 pp. Presents information on stainless, alloy and spring steels, clad metals, conversion facilities and products. Superior Steel Div, Copperweld Steel Co, Carnegie, Pa.

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(B-68) **Perforated Metal**—Catalog, 32 pp. Shows hole shapes and sizes, sheet textures. Illustrates applications such as soundproofing, grills, containers. Diamond Mfg. Co, Wyoming, Pa.

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SPECIALTY WIRE is engineered for the most difficult applications by National-Standard. Just a few of the many specialties are: drawn wire in fine sizes of titanium, stainless and high carbon steel; electro-coated steel wire with nickel, copper, brass and other coatings; a wide variety of finishes such as bright, galvanized, liquor, tin, bronze, etc.; music spring wire; special-purpose wire strand and flat and tubular braid in steel and other metals; and high-temperature alloy wires such as Inconel-X.

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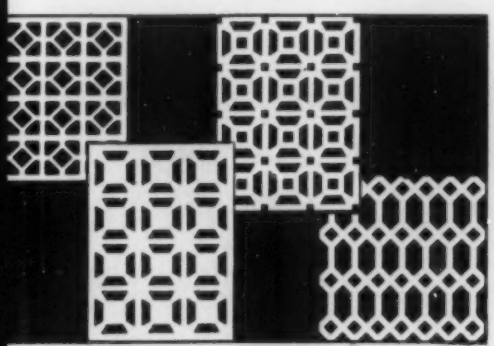

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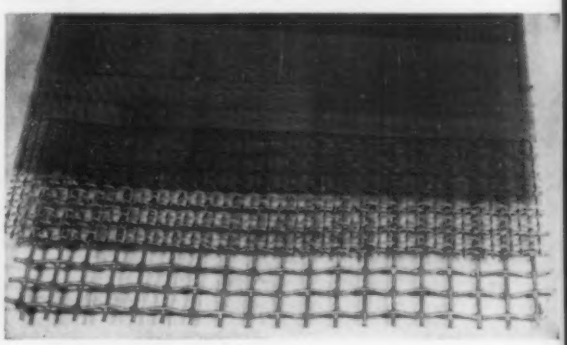

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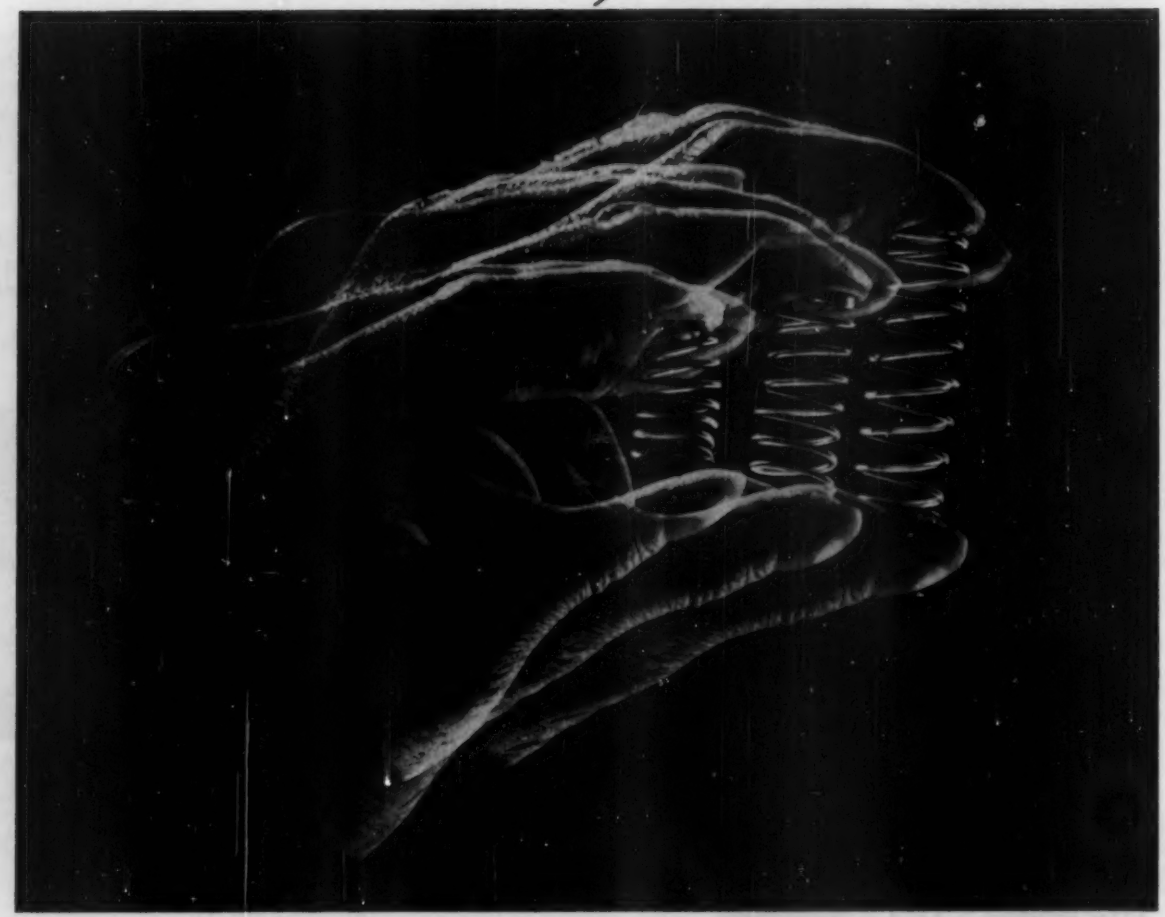

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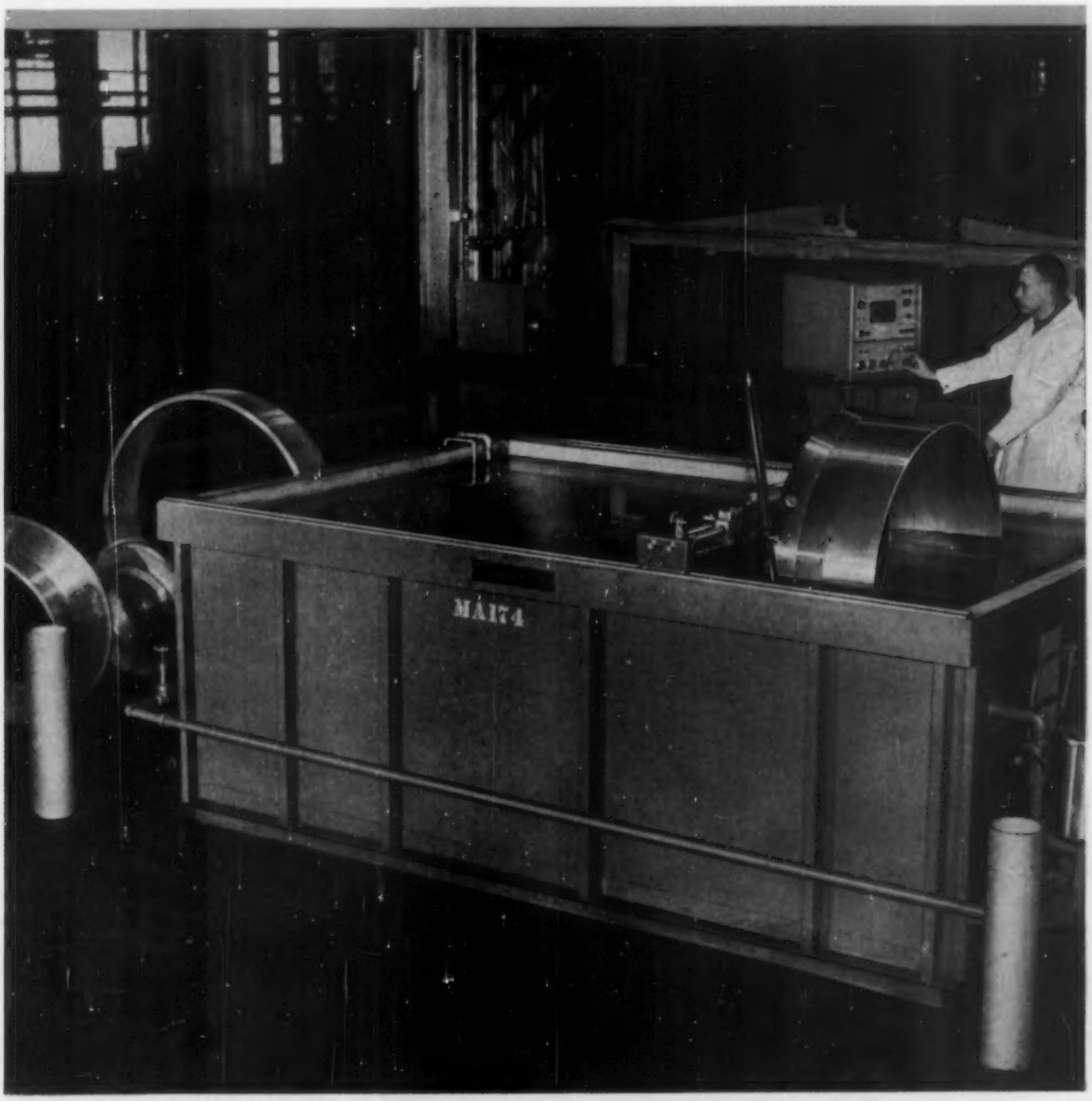

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Missile's "Fast Draw" Starts

Cold-drawn Seamless Cuts Clean-up Costs For Anker-Holth's Power Cylinders

The Missile Age version of the "fast draw" starts with the lightning stroke of a power cylinder.

Big, 12-foot stroke hydraulic cylinders provide the power and speed that unsheath one of the nation's principal defense missiles for instantaneous action.

They're made by Anker-Holth Division of The Wellman Engineering Company from Pittsburgh Steel Company's commercial quality, carbon steel, Seamless Mechanical Tubing.

Mounted two to a unit, the husky cylinders must—within seconds, and without fail—slide back the two halves of the hangar-size missile shelter to release the weapon for firing.

Anker-Holth, of Port Huron, Mich., uses Pittsburgh Steel's Seamless Mechanical Tubing to manufacture this critical unit's outer cylinder and piston rod.

Relies on Pittsburgh—What makes this company rely on Pittsburgh Steel for the tubing it requires for this application?

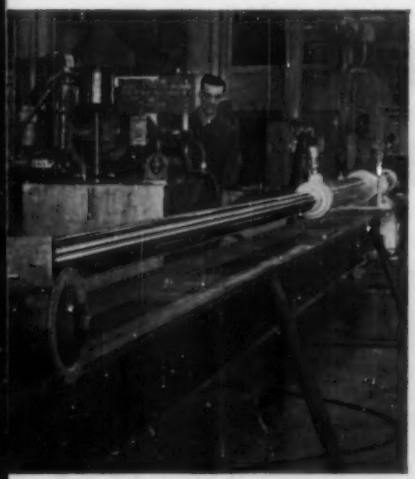
Fred J. Theisen, vice president-production, says there are several reasons. He explains:

"First is Pittsburgh Steel's service. They're able to give us information fast.

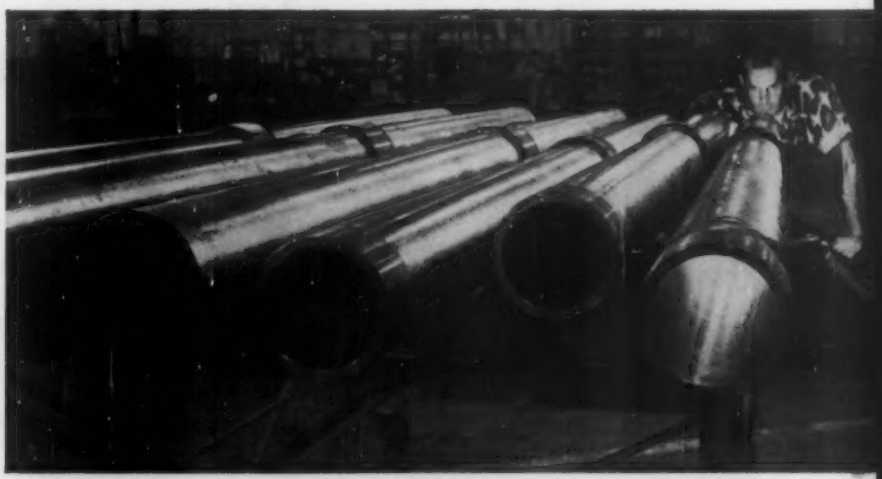
"On the first lot of tubing for this job, we asked all our suppliers for recommended sizes for cleanup to our finished dimensions. Pittsburgh

Piston rod made by Anker-Holth for launcher shelter's roof activating cylinder requires only minimum processing for cleanup with commercial quality Pittsburgh Steel Seamless Mechanical Tubing. Finished rods, 142" long, are plated with hard chrome. Vice president-Production Fred J. Theisen, (left) talking with Pittsburgh Steel salesman T. J. Whan, says Anker-Holth relies on Pittsburgh Steel tubing for this missile component.

With Pittsburgh Steel's Tubing



Final hydraulic testing on completed cylinders is comprised of 30 cycles at 4,500 psi—using special Anker-Holth testing equipment.



Fast service, straightness, and minimum stock removal convinced Anker-Holth that "Pittsburgh was best we could get for this job." Cylinder measures 5 inches by 4 inches by 143 inches. Anker-Holth specializes in power cylinders with bores from one to 48 inches, and strokes to 45 feet.

Steel's answer was in first, and it suggested less stock removal.

"That's important, and it's one reason Pittsburgh Steel stays with us. We ask them for size recommendations that we need for cleanup. They tell us the size, and they do it in a hurry. They don't wait around for a couple of months to reply.

"For another thing, when we first started production of this cylinder, we had a problem of straightness.

"I don't know how they did it, but Pittsburgh Steel came through with a batch of tubing I had never seen the equal of. Pittsburgh makes a quality tube. Straightness is the big thing—plus service and the amount of stock we must remove. With Pittsburgh Steel Seamless Tubes we don't need extra metal for honing—so we aren't paying for metal we don't use."

Experience Pays—Close attention to customers' needs and experience, plus steelmaking skills and production practices developed in nearly 50 years of seamless tube production, make Pittsburgh Steel able to serve Anker-Holth this way.

In this instance, Pittsburgh Steel's ability to produce commercial quality cold-drawn seamless mechanical tubing to exacting standards for straightness, concentricity and tolerances, allows Anker-Holth to simplify its cleanup process of the cylinder's ID and centerless grinding of the piston rod's OD.

Machinability and weldability of Pittsburgh Steel's tubing are vital factors in Anker-Holth's production, too, because plugs, ports, sleeves, piston and end covers are threaded and/or welded to the piston rod and cylinder in this application.

Contact one of the distributors or district sales offices listed below. Then let Pittsburgh Steel Company demonstrate its ability and readiness to help. You, too, will find that Pittsburgh Steel's tubing is the best you can get.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
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Chicago Tube & Iron Company
Chicago, Illinois

Cleveland Tool & Supply Co.
Cleveland, Ohio

Drummond, McCall & Co., Ltd.
Montreal, Quebec, Canada

Edgcomb Steel Company
Philadelphia, Pennsylvania

Gilmore Steel & Supply Co.
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Miller Steel Company, Inc.
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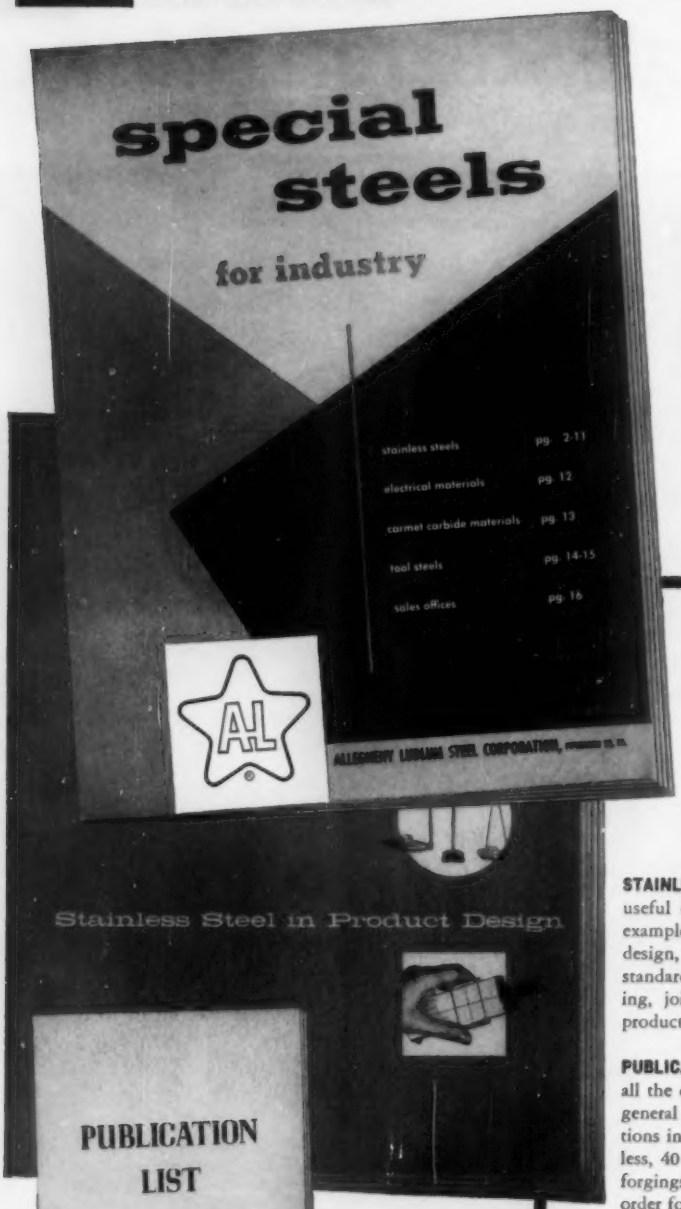

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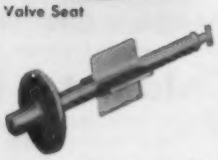
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catalogs and bulletins.....continued

(B-95) **Roll Formed Shapes**—Brochure, 8 pp. Illustrates some sections. Gives sizes of butted and lockseam tubing. Notching and finishing also done. Roll Formed Products Co, 3768 Oakwood Ave, Youngstown, Ohio.

(B-96) **Self-lubricating Metal**—Brochure, 4 pp. Presents mechanical properties, applications, machining instructions, wear rate curves for a powdered metal and graphite material. Deva-Metal Div, S K C Research Associates, 445 Fifth Ave, Paterson 4, NJ.

(B-97) **Rhodium Plating**—Bulletin, 20 pp. Describes equipment and explains how to use electroplating solutions. Sel-Rex Corp, 75 River Rd, Nutley 10, NJ.

(B-98) **Platinum Plating**—Bulletin, 4 pp. Furnishes instructions for using and discussion of advantages of platinum electroplating solutions. Sel-Rex Corp, 75 River Rd, Nutley 10, NJ.

(B-99) **Centrifugal Castings**—Brochure, 8 pp. Describes process and facilities for producing nonferrous castings. Chart of alloy properties included. Wisconsin Centrifugal Foundry, Inc, 905 E St Paul Ave, Waukesha, Wisc.

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(B-101) **Decorative Gold Plating**—Bulletin, 7 pp. Provides instructions for using solutions that produce several different tones. Sel-Rex Corp, 75 River Rd, Nutley 10, NJ.

(B-102) **High Temperature Gold Plating**—Bulletin, 4 pp. Instructs in use of solutions which plate for high temperature applications or electroforming. Sel-Rex Corp, 75 River Rd, Nutley 10, NJ.

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(B-104) **Stainless Steel**—Brochure, 31 pp. Describes composition and properties of some 200, 300 and 400 series. Sharon Steel Corp, Sharon, Pa.

(B-105) **Bars and Tubes**—Bulletin, 6 pp. Gives alloy properties and range of sizes of centrifugally cast bars and tubes. The Shenango Furnace Co, Centrifugally Cast Products Div, W Third St, Dover, Ohio.

(B-106) **Nonferrous Centrifugal Castings**—Bulletin, 4 pp. Furnishes alloy analyses and properties. Shows casting and machining capabilities. The Shenango Furnace Co, Centrifugally Cast Products Div, W Third St, Dover, Ohio.

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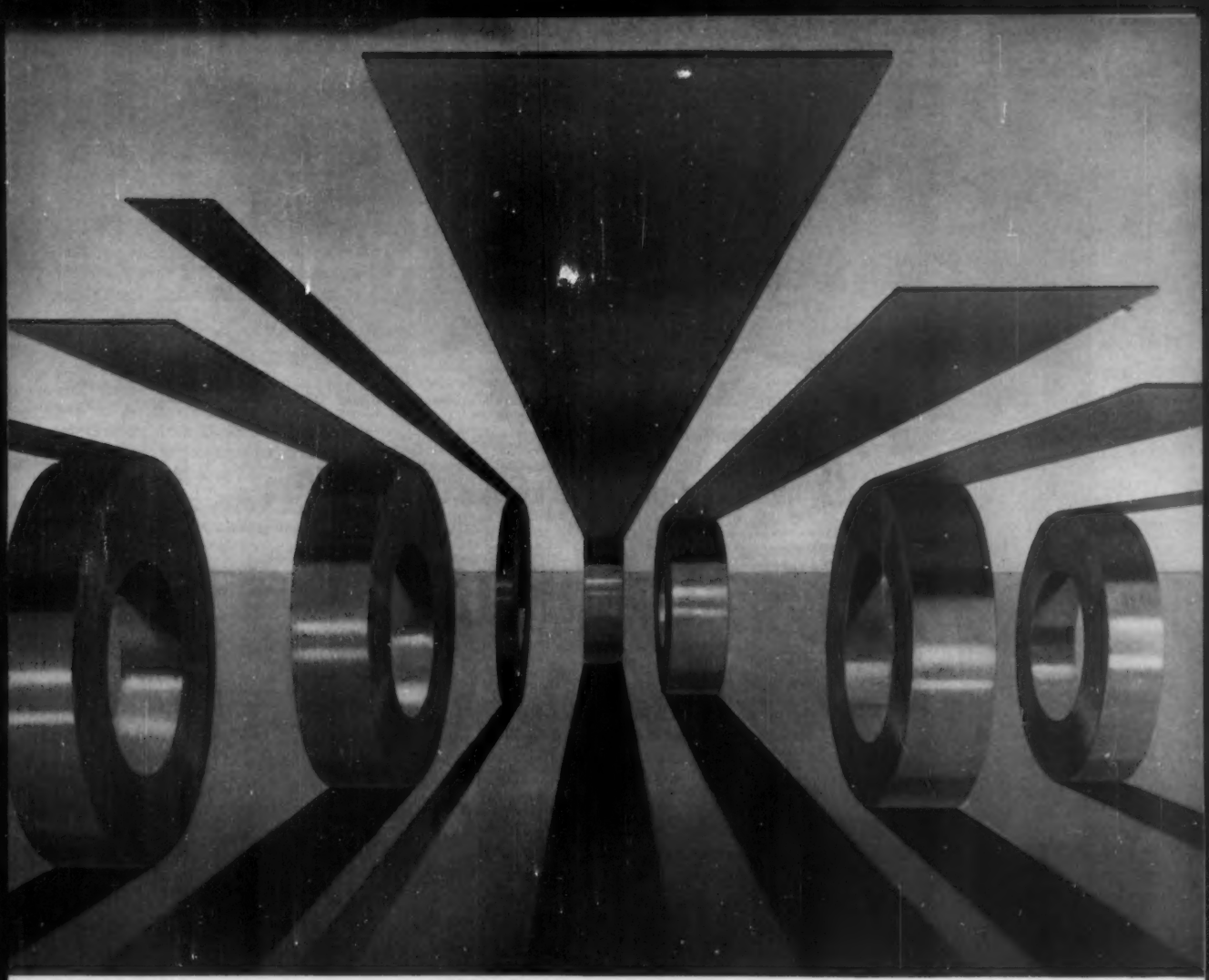

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catalogs and bulletins.....continued

(B-107) **Brazed Honeycomb**—Brochure, 22 pp. Shows manufacturing methods, uses, properties of brazing alloys and core foils. Solar Aircraft Co, 2200 Pacific Hwy, San Diego, Cal.

(B-108) **Alloy Steels**—Catalog, 24 pp. Furnishes analyses, properties, instructions for heat treatment. Includes applications guide, weight table and hardness conversion table. Wheelock, Lovejoy & Co, Inc, 128 Sidney St, Cambridge, Mass.

(B-109) **Ultrahigh Strength Steel**—Brochure, 16 pp. Discusses properties and fabrication of a cobalt modified steel for rocket propellant chambers and similar uses. Universal-Cyclops Steel Corp, English Ave, Bridgeville, Pa.

(B-110) **Precipitation Hardening Tubing**—Bulletin, 4 pp. Describes small diameter tubing made of stainless steel alloy containing molybdenum. Superior Tube Co, Norristown, Pa.

(B-111) **Electroplating Gold**—Brochure, 5 pp. Discusses characteristics of the 24Kt plating, and methods of plating and testing. Technic, Inc, 88 Spectacle St, Cranston, RI.

(B-112) **Aluminum Coating**—Brochure, 4 pp. Describes hot-dip coating of ferrous metals with aluminum to protect against chemical and high temperature corrosion. Arthur Tickle Engineering Works, Inc, 21 Delevan St, Brooklyn 31, NY.

(B-113) **Centrifugal Castings**—Catalog, 23 pp. Gives properties and uses of bronze, brass and aluminum alloys. Outlines casting capabilities of company. Torrance Brass Foundry, Inc, 1825 W 213 St, Torrance, Cal.

(B-114) **Welded Tubing**—Catalog, 48 pp. Provides tables of physical, chemical and electrical properties, sizes, weights and other data for welded stainless steel and high alloy tubing and pipe. Trent Tube Co, 498 S Church St, E Troy, Wisc.

(B-115) **Pipe and Tubing**—Catalog, 47 pp. Provides table of sizes, weights, corrosion data and analyses of stainless and high alloy steels. Sizes range from $\frac{1}{8}$ to 40 in. OD. Uses vary from chairs to heat exchangers and chemical piping. Trent Tube Co, 498 S Church St, E Troy, Wisc.

(B-116) **Small Tubing**—Bulletin, 12 pp. Gives manufacturing capabilities for ferrous and nonferrous tubing as small as 0.005 in. OD. Uniform Tubes, Inc, Collegeville, Pa.

(B-117) **Powdered Metal Parts**—Brochure, 8 pp. Briefly explains production process. Graphs and charts give design values for powdered metal bearings. US Graphite Co, Saginaw, Mich.

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Tantalum	Metal—99.9% (capacitor) grade. Solid form—strip, bar, wire. Metal—99.5% grade. Granules. Metal Powder—99.8% grade. Fine powder. Oxide—99% grade. Fine powder.	Anodes: Sintered for both liquid and solid electrolytic capacitors, wide range of sizes. Strip: .001″ to .100″ thick, up to 12″ wide. Wire: From .005″ to .030″. Powder: 200 mesh. Other sizes available. Oxides: In analyses and particle sizes to meet specific requirements.

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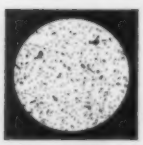
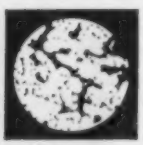


Bearium Metal



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(B-118) Seamless Mechanical Tubing—Bulletin, 24 pp. Lists sizes, wall thicknesses, surface finishes, applications and formed tube shapes. National Tube Div, US Steel Corp, 525 William Penn Pl, Pittsburgh 30.

(B-119) Low Temperature Brazing Alloys—Bulletin, 12 pp. Presents tables of brazing alloy charactertistics and discusses silver alloy brazing process. United Wire & Supply Co, Elmwood Ave, Providence 7, RI.

(B-120) High Temperature Steels—Brochure, 32 pp. Examines properties and fabrication of two 5% chromium steels for aircraft and missiles. Universal-Cyclops Steel Corp, English Ave, Bridgeville, Pa.

(B-121) Welded Steel Tubing—Brochure, 4 pp. Gives gauge, OD, weight per ft for round steel tubing. Wheatland Tube Co, 1300 Bankers' Securities Bldg, Philadelphia 7.

(B-122) High Temperature Metals—Brochure, 48 pp. Describes processing of the metals and composition, properties and fabrication of each alloy. Universal-Cyclops Steel Corp, English Ave, Bridgeville, Pa.

(B-123) Prealloyed Metal Powders—Brochure, 9 pp. Tells alloy types available and gives properties of several steel powders. Includes tooling tips. These metals are alloyed before being powdered. Vanadium-Alloys Steel Co, Latrobe, Pa.

(B-124) High Strength Steel—Brochure, 24 pp. Presents discussions of properties, special treatments, fabricability, welding of steel suggested for high temperature aircraft use. Vanadium-Alloys Steel Co, Latrobe, Pa.

(B-125) Tool Steel—Catalog, 60 pp. Lists chemical composition, heat treatment, properties and applications of metals for dies, cutting, molds. Vanadium-Alloys Steel Co, Latrobe, Pa.

(B-126) Porous Chromium—Brochure, 12 pp. Describes electroplated chromium with pores for oil retention. Used on cylinder liners. Van der Horst Corp of America, Box 557, Olean, NY.

(B-127) Colored Stainless Steel—Brochure, 8 pp. Furnishes mechanical properties of stainless steel with baked organic coating. Gives physical, weathering and washability test results. Washington Steel Corp, Washington, Pa.

(B-128) Copper Base Alloys—Catalog, 64 pp. Tables give analyses and properties of nickel silvers, phosphor bronzes and special alloys plus tolerances for sheet, strip and coils. Also includes facilities and reference tables. Waterbury Rolling Mills, Inc, Waterbury, Conn.

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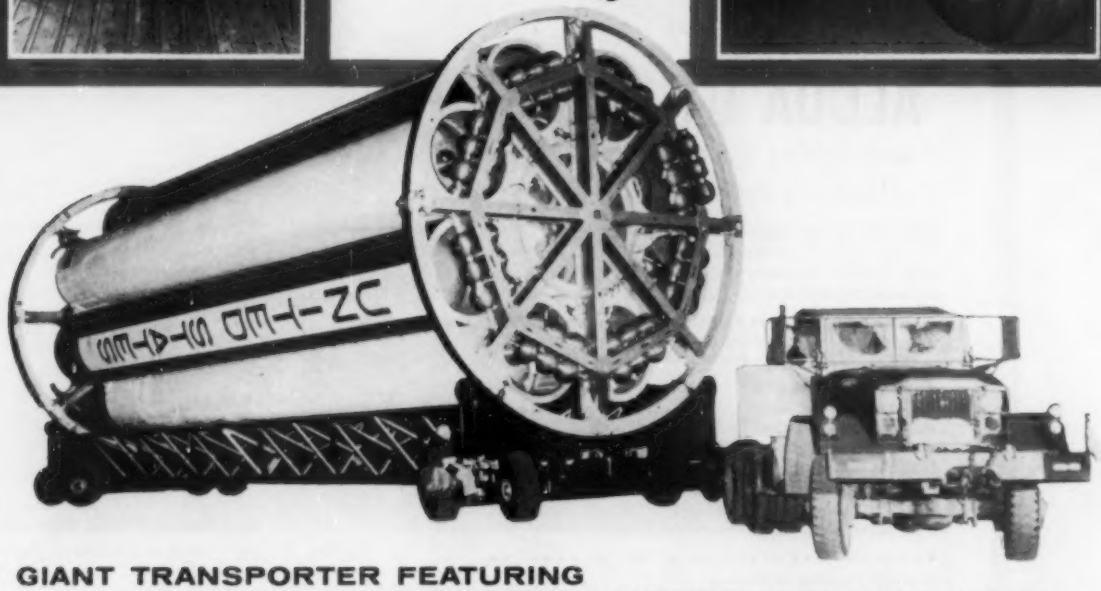

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(B-129) Zinc-coated Steel Sheet—Brochure, 20 pp. Prevents applications and advantage of dipped and electrolytically coated sheet. Lists gages and widths available, manufacturing forming processes possible. Weirton Steel Co, Main St, Weirton, W Va.

(B-130) Steel Castings—Brochure, 6 pp. Gives all ASTM specifications which apply. Steel Founders' Soc of America, 606 Terminal Tower, Cleveland.

(B-131) Small Metal Tubing—Bulletin, 12 pp. Gives materials characteristics, suggested uses for tubing from 2½ in. to 0.012 in. OD. Superior Tube Co, Norristown, Pa.

(B-132) Special Steels—Brochure, 14 pp. Gives analyses for saw steels and stainless steels. Discusses other types such as heat resisting, soft center, clutch and high strength steels. Ingersoll Steel Div, Borg-Warner Corp, New Castle, Ind.

(B-133) Magnesium Mill Products—Brochure, 8 pp. Briefly describes magnesium alloy sheet and plate, tooling plate, foundry pattern plate and boron carbide aluminum clad with pure aluminum. Brooks & Perkins, Inc, 1950 W Fort St, Detroit 16.

(B-134) Dictionary of Steel Terms—Bulletin, 34 pp. Combines text, tables, curves and photographs to explain terms from age hardening to yield strength. La Salle Steel Co, Chicago 80.

(B-135) Cold Finished Steel Bars—Bulletin, 12 pp. Shows chemistry, physical properties, machining speeds and feeds for automatic screw machines. Steel is severely cold-worked, furnace treated and has copper added for machinability. La Salle Steel Co, Chicago 80.

(B-136) Fatigue-resistant Steel Bars—Bulletin, 24 pp. Curves and tables provide data on strength, machinability and fatigue. Process includes elevated temperature drawing. La Salle Steel Co, Chicago 80.

(B-137) Machining Time—Bulletin, 6 pp. Discusses parts cost as determined by material cost and machinability. Includes sample calculations and graph. La Salle Steel Co, Chicago 80.

(B-138) Seamless Steel Tubing—Catalog, 56 pp. Gives properties and dimensions of cold drawn tubing for mechanical, pressure and aircraft uses. Includes description of processes and practices plus reference tables. Michigan Seamless Tube Co, S Lyon, Mich.

(B-139) Residual Stresses—Bulletin, 28 pp. Full title is *Residual Stresses in Cold-finished Steel Bars and Their Effect on Manufactured Parts*. La Salle Steel Co, Chicago 80.

SECTION C

NONMETALLIC MATERIALS AND FINISHES

Design Abstracts 104

Refractory Materials Today 106

Designing for Simpler Metal Finishing Techniques
by Adrian Walmsley 108

Quick Facts About Porcelain Enamel 112

9 Plastic Foams
by C. R. Davall 113

Lignum Vitae—A Unique Engineering Material 115

Plating Nickel on Aluminum Alloys
by James T. N. Atkinson 118

DESIGN ABSTRACTS

ABLATION MATERIALS

Ablation is a complex process, involving either sublimation or combined melting and vaporization, as well as decomposition, combustion, and chemical reaction between components in the boundary layer. Desirable properties in ablation materials are: low molecular weight gases as final product of decomposition; high endothermic enthalpies of decomposition; high activation energies for decomposition; small temperature differences between melting or softening point and vaporization point; high liquid viscosity and specific heat, low liquid thermal conductivity; high specific heat for solid; low thermal conductivity for solid; no residual solids upon pyrolysis. Low molecular-weight gaseous-decomposition products are desirable because of their large heat capacity and diffusion coefficients. The large amounts of gas, which form in the boundary layer, tend to exert a blocking action reducing the rate of heat transfer.

"Evaluation of Ablation Materials for High Temperature Application," Schwartz, Bandaruk, and Mills Aeronautic Div, Ford Motor Co. SAE paper 98T, SAE, 485 Lexington Ave, New York 17.

*

Stress Limits for Thermoplastics

Describes a testing procedure that will define the relationship among such design variables as stress magnitude, length of time of stress application, temperature of part and the amount of relaxation and creep that occurs in thermoplastic structural components.

"Working Stress Limits for Thermoplastic Structural Components," Harris and Burlew, Dow Chemical Co and McGarry, MIT. SPE paper 8-1. Society of Plastics Engineers Inc, 65 Prospect St, Stamford, Conn.

*

Ultraviolet vs Structural Plastics

Space vehicles and their component materials at extreme altitudes will be exposed to environments of greatly reduced pressure and intense solar radiation. Experimental studies were conducted on the effects of combined environments of heat, low pressure and ultraviolet radiation on the change in weight and flexural strengths of glass reinforced polyester, epoxy and phenolic laminates. All plastics lost weight; some gained in strength and others lost 25-30% in flexural strengths.

"Influence of Ultraviolet and Vacuum Environments on Structural Plastics," Harold M. Preston and Norman E. Wahl, Cornell Aeronautical Laboratory Inc, Buffalo 21, NY. Proceedings of the Institute of Environmental Sciences, Box 191, Mt Prospect, Ill.

*

Structural Design of Plastics

In the first part of this article, the mechanical properties of plastics of particular interest to the designer of structural parts are discussed. Included are analyses of such factors as the stress-strain curve; effect of temperature and loading time and environment; yield point; tension, compression and flexure. In the second part, devoted to design methods, means of applying the mechanical properties and concepts presented earlier are described and illustrated. Typical formulas for designing within the modulus accuracy limit are given, as well as curves on such factors as beam deflection and max load capacity.

"Structural Design of Plastics," Baer, Knox et al, E I du Pont de Nemours & Co. SPE Journal, April '60, 65 Prospect St, Stamford, Conn.

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Plastic Colorants

Manufacturers and end-users have always been aware that color in plastics means dollars and cents in terms of the intangible "visual appeal" that moves goods off the shelves. Choosing the right colorants and coloring techniques can also be translated into dollars and cents by expediting production and satisfying the customer. The best way to achieve this commercial and economic success is to: know the coloring industry and how it services the plastics industry; and know the advantages and limitations of available colors, colorants, and coloring techniques. This article is a complete guide.

"How to Choose the Correct Colorant," Modern Plastics, April 1960, 575 Madison Avenue, New York 22.

*

Acetal Resins

Properties, methods of processing and applications of the group of plastic materials known by the trade name, "Delrin," are reviewed.

"Acetal Resins," G. F. C. Barrett, Du Pont Co Ltd, Plastics, April '60, Bowling Green Lane, London EC 1, England.

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Producing Special Properties in Epoxies with Fillers

How fillers such as silica, mica, calcium carbonate, zirconium silicate, powdered metals can effect insulating qualities, shrinkage rates, thermal expansion, heat dissipation, self-extinguishing characteristics, resin viscosity, foam density of epoxy resins.

"Producing Special Properties In Plastics with Fillers," Formo and Isleifson, Minneapolis-Honeywell Regulator Co. SPE Journal, Aug 1959, 65 Prospect St, Stamford, Conn.

*

Sandwich Structure Exposure

This paper summarizes a portion of a program consisting of three-year exposures of a variety of types of sandwich construction and core materials at two separate test sites. One at Kure Beach, North Carolina, had a natural environment that included exposure to a salt water atmosphere, direct rays of the sun, wind driven sand, and several seasons of hurricanes. The second site on typical farm land at State College, Pennsyl-

vania, had an environment of the normal weather of the northeastern United States, including exposure to sun, wind, rain, snow, and ice.

"Effect of Natural Environment on Sandwich Structure Using AMS 3722 Paper Honeycomb Core," by Robert F. Zemer, Materials Research & Process Engineering, Douglas Aircraft Co, Inc. ASTM Paper No. 83.

*

Significance of Surface Finish

Dimensional values for surface condition are discussed, surface waviness is illustrated, technique of taper sectioning to reveal surface ridges is described, and the significance and geometry of surface roughness are analyzed.

"Significance of Surface Finish on Friction Wear and Lubrication," A. Sonntag, Alpha-Molykote Corp; presented at Seminar on Friction, Lubrication and Wear, Burgenstock, Switzerland, Sept 17-18. Available from Alpha-Molykote Corp, Stamford, Conn.

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Influence of Surface Properties on Corrosion Resistance

In an effort to determine reason for difference in corrosion resistance of steel sheet used for automotive body panels, steel chemistry was analyzed, hardness measured, surface condition checked. Although investigation did not rule out other factors, substantial evidence was developed that lead contamination was an important cause.

"Influence of Variations in the Surface Properties of Steel on the Corrosion Resistance of Body Panels," Gene L. Leithauser, General Motors Research Laboratories, SAE paper 134A. SAE, 485 Lexington Ave, New York 17.

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Self-extinguishing Plastics

Wall chart lists all self-extinguishing elastomer compounds available at time of publication. It is broken down into three sections: resins and molding compounds; film, sheeting and laminates; plastic foams. Tradenames, tests passed, properties, manufacturers names are given.

"Modern Plastics Chart of Self-extinguishing Plastics Materials." Modern Plastics, Nov '59, 575 Madison Ave, New York 22.

*

How Surface Condition Affects Paint Performance

The condition of the surfaces of steel products produced and finished by various processes and materials are discussed. Describes methods of identifying type of surface contamination, and suggests means of altering steel production practices to improve surface quality.

"The Influence of Cold-rolled Steel Surfaces on Paint Performance and Paint Testing," G. W. Grossman, Jr, Q-Panel Co; Official Digest of Federation of Societies for Paint Technology, Dec '59, 121 S Broad St, Philadelphia 7.

*

Rolling Friction of Polymers

Coefficients of friction for rolling of steel balls on butyl, silicone and neoprene are given, for the temperature range 77 to 212 F. Evaluation of the results reported indicate that, for equivalent amounts of deformation, rolling friction is directly proportional to dynamic mechanical losses measured by a rebound method.

"Rolling Friction of Polymeric Materials," Donald G. Flom, General Electric Research Laboratory. Journal of Applied Physics, Feb '60, 335 E 45th St, New York 17.

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Surface Specifications

Some degree of surface irregularity is inevitable and often desirable. The extent to which finish is controlled depends largely on an understanding of surface specifications and their application.

Surface specifications, like tolerances, should convey a specific idea from the designer to the tool engineer, but quite often improper use of surface specifications results in mutual disagreement. The principal reason for this is the use of an incomplete specification. Surface specification includes seven separate values: Waviness height and width; max and min roughness; roughness width; roughness-width cutoff; lay. In 90 per cent of all cases only one is required, and in 99 per cent of all cases only one is specified. It is in the cases where a more complete specification is required—and not specified—that problems arise.

"Surface Specifications . . . Their Use and Meaning," Charles H. Good, Micrometrical Mfg Co, The Tool Engineer, Oct 1959, 10700 Puritan Ave, Detroit 38.

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Radiation of Silicone Greases

Silicones as a class have been termed poor in radiation stability. This refers to silicones containing a major amount of methyl substituents and little or no phenyl substitution. Actually, some fluid silicones are very stable in radiation environments. This report points out the degree of radiation stability of these fluids and the extrapolation of this characteristic to grease formulations.

"Radiation Stability of Silicone Greases," Fischer, Zack Jr. and Warrick, Dow Corning Corp; Lubrication Engineering, Oct '59, 5 N Wabash Ave, Chicago 2.

*

Comparing Glass and Organic Fibers

An epoxy resin system commonly used in laminates was selected for tests which involved comparison of unreinforced resin laminate with other specimens reinforced with glass fiber and Dacron fiber. Results of flexural, tensile impact, thermal expansion and certain dynamic mechanical tests are given. Glass gives strength and stiffness; Dacron, flexibility and toughness.

"Reinforcing Action of Glass and Organic Fibers in Epoxy Laminates," C. D. Doyle, General Electric Co; Modern Plastics, Nov '59, 575 Madison Ave, New York 22.

From: Technical Memorandum

REFRACTORY MATERIALS TODAY

How metals, metal oxides, carbides, graphite and modern cermets perform at high and low temperatures.

Refractory materials—those melting above 1800 C—are important not only in rockets, gas turbines and ram-jets, but also in metal processing, chemical processing, glass making and electronics. The wide-ranging field of refractory materials includes: Metals, carbides, oxides, nitrides, silicides, borides, sulfides, intermetallic compounds and graphite.

Strength, oxidation resistance, and resistance to thermal shock at high temperatures are properties aimed at in the development of these materials. This rundown of recent research is supplemented with charts that give significant design information.

GENERAL PERFORMANCE

Molybdenum and molybdenum-base alloys are promising refractory metals but oxidize badly. Diffusion coatings and cladding in single and multiple layers of silicon, aluminum, molybdate, chromium and nickel improve performance. Perfect coatings are difficult to achieve.

Metal oxides retain strength at higher temperatures than refractory metals, but withstand thermal shock poorly. To obtain both strength and resistance to thermal shock ceramics are bonded with refractory metal—alumina-chromium is a typical cermet resulting from such a bond.

Carbides, nitrides, borides, silicides and sulfides can, generally, withstand thermal shock better than oxides. Metal-bonded titanium carbide has received the most attention in recent development work.

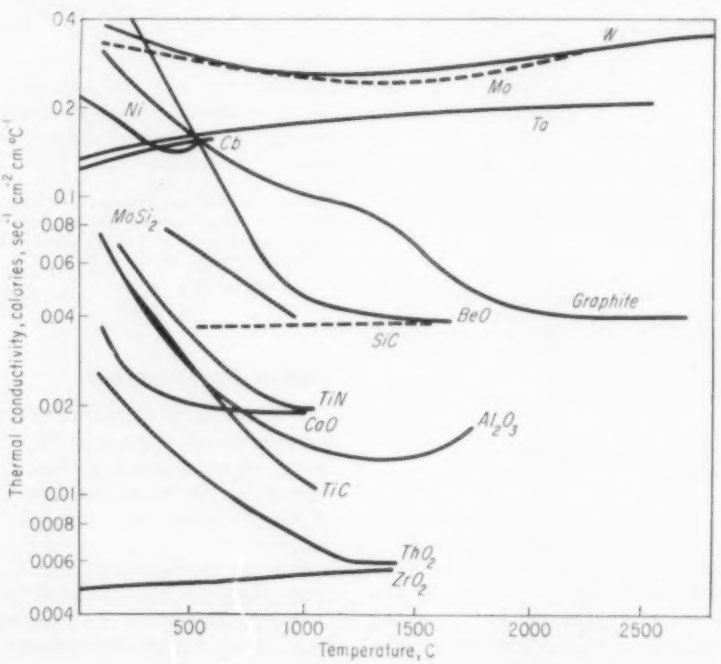
Recent developments in cermets have led to "reinforced" metals with as low as 1-2% oxide. Poor thermal shock resistance of the high-ceramic cermets is thereby avoided, while the small percentage of oxide raises the useful load-bearing temperature of the binding metal.

Graphite gives good performance for extreme temperature service in furnace linings and electrodes, rockets, and ram jets. A painted and fired sulfide coating protects the graphite against oxidation.

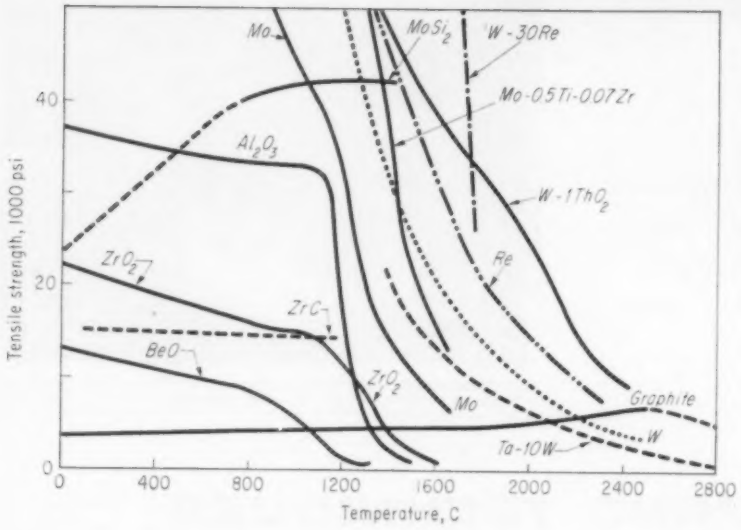
FABRICATION

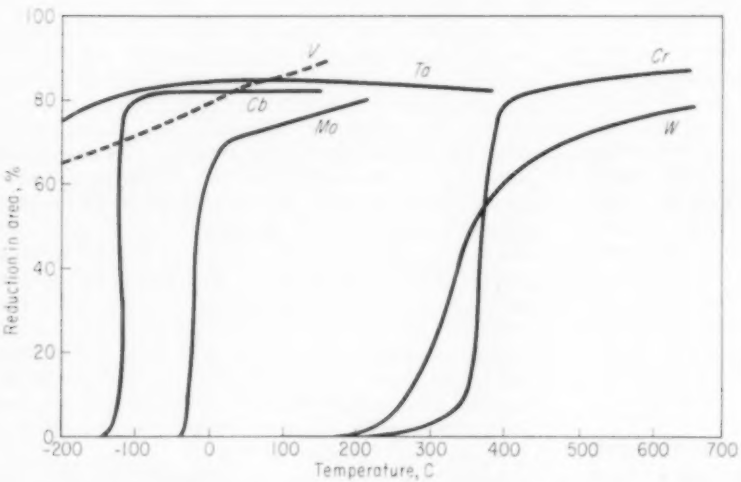
Although many refractory metals can be fabricated by cold working there are some important exceptions. For example, cast tungsten and molybdenum must be hot extruded preliminary to final hot working in dies or rollers. These two metals are brittle at low temperatures so must be mechanically joined. Other metals can usually be welded. A new technique used successfully with nickel is rolling sheet from powder.

Most nonmetals have to be processed into their structural shape. Some powders are pressed—dry or with a plasticizer such as wax. When a liquid vehicle is used, it is either evaporated during sintering or, as in



THERMAL SHOCK: THERMAL CONDUCTIVITY is a good gauge of how well a material can withstand thermal shock. The thermal shock parameter most often used is σ K/ α E, where σ is fracture strength; K, thermal conductivity; α, coefficient of thermal expansion, and E is elastic modulus. With wide operating temperature ranges there is danger of exceeding the plastic limit. Therefore, α is most important. As high a parameter value as possible is desired. Judged by thermal conductivity, metals are best, oxides worst; metals with the highest melting points have the lowest coefficients of thermal expansion. There is no correlation for nonmetals. Overall, metals are best, followed by graphite, beryllium oxide and silicon carbide.





AT LOW-TEMPERATURES metals are more ductile than intermetallic compounds and nonmetals. The best intermetallic compounds are about equal to the worst metals. It is best for the transistion temperature—when metals change from ductile to brittle state—to be low. Metals are improved by purification, decreasing grain size or alloying as in the case of adding rhenium to molybdenum and tungsten.

slip casting, absorbed by a porous mold. Slip casting has been used to make metal shapes not adapted to forging, but mechanical properties of slip-cast parts are inferior to hot-worked parts. Vapor deposition process produces columnar-shaped parts of pyrolitic carbon, or boride and silicide coatings. Joining of nonmetals is unexplored.

FUTURE

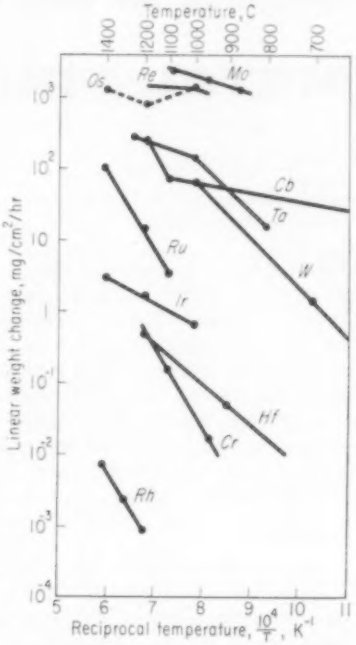
Future development of refractory metals should bring greater high temperature strength, improved oxidation resistance and coatings allowing short periods at extreme temperatures. Fabrication advances will mean large sheets, forgings and extrusions.

Nonmetals will be produced with higher purity and lower porosity, relieving low strength problems a little. Intermetallic compounds as bases for alloying will give better strength at elevated temperatures.

REFERENCE:

Refractory Materials, DMIC Memorandum 44. Published by Defense Metals Information Center, Battelle Memorial Institute, 505 King Avenue, Columbus 1, Ohio.

HIGH TEMPERATURE STRENGTH of refractory metals is improved by cold working, solid solution alloying, interstitial solution or dispersion of insolubles. Materials with the highest melting points have the best high temperature strength. Above the recovery temperature metal strength drops rapidly. Similar behavior occurs with nonmetals at about 60% of absolute melting point. Below recovery and recrystallization temperature cold working increases strength. At higher temperatures and high strain rates, decreasing grain size increases strength. But at lower strain rates and high temperature, decreasing grain size decreases creep strength. For maximum creep resistance at highest possible temperatures large grain size helps. Strength increases with temperature for many nonmetals, including graphite and $MoSi_2$.



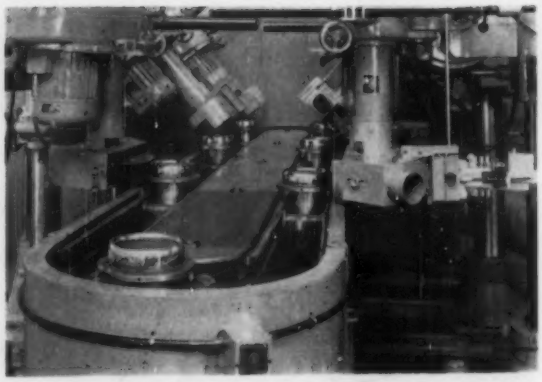
FOR OXIDATION RESISTANCE at high temperature rhodium is the only refractory metal with outstanding properties. Alloying improves oxidation resistance of metals, but usually at a cost of poorer high temperature strength and fabrication properties. Oxidation resistance of metals with high melting oxides is improved by alloying with metals of higher valence. Other alloying metals increase the time during which protective scales adhere, or form spinels[1] in place of base metal oxides. For long periods over 1000C protective coatings are required.

Most oxides are good up to their melting points. Silicides of higher molecular weight are good. Molybdenum silicide—better above 900 C than below—has received most attention. Graphite requires coating above 600 C. The rest of the nonmetallic compounds, carbides, borides, nitrides and sulfides are poor, but several are inert under other than oxidizing conditions.

[1]Spinels are compounds of the form XOR_2O_4, where X is the base metal and R is the alloying metal.

From: Engineering Materials and Design

Polishing, plating and painting of components can be needlessly complicated by the designer who fails to understand the limitations of the various processes. Here are some of the pitfalls to avoid.



AUTOMATIC-RETURN-TYPE polishing machine, fitted with six adjustable polishing heads. It is thus possible to speed up polishing of either simple or complex shapes.

designing for simpler

METAL FINISHING TECHNIQUES

ADRIAN WALMSLEY
Chairman
North Western Branch
Institute of Metal Finishing

One of the most important factors affecting the finishing of metals is really the design stage of the component. Indeed, it is one of the ever-recurring problems of a metal finisher, when presented with a particularly difficult object to polish, plate or paint, that he was not consulted earlier about the design. Often this would have enabled him to offer alternatives for considerably simplifying his task, cheapening the process and, at the same time, producing a shape more streamlined for sales appeal, without in any way affecting its function.

POLISHING

For decorative finishes, the initial process is most likely to be a polishing operation. This can be done by hand, by automatic machine or by a combination of both methods.

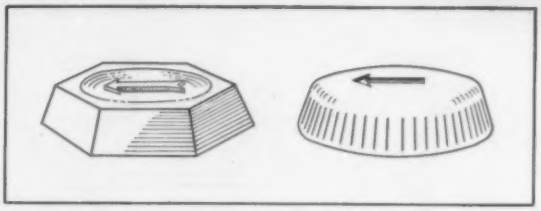
The objects are progressively smoothed, using graded abrasives either on finishing bands or on felt "bobs" prepared by the polisher himself. These polishing wheels are usually about 1 in. or 2 in. thick and 10-in. or 12-in. diameter, although the range of diameter can vary from 1 to 22 in. In use, the diameter decreases with wear. Below about 6 in. diameter, the peripheral speed has dropped so much (most polishing machines being of constant speed) that economical polishing is no longer possible; the designer should thus keep in mind that a surface to be polished in this way should be such that it can be touched by a wheel of 6 to 12 in. diameter. As this operation is the most costly of the finishing operations, the area, the shape and the surface condition of the metal all affect the time taken, and hence the cost, Fig. 1. Area should thus be as small as possible and surface condition as good as possible. Here, accidental damage such as scratches from careless handling in previous operations can be extremely difficult to remove. In general, the softer the metal, the easier the polishing. However, these softer metals, particularly zinc and aluminum alloys, are chemically active metals and require special plating techniques, with relatively thick coats of copper, nickel and chromium to give complete protection, which may offset any saving in polishing costs. The intended environment of the finished component also has a bearing on the base metal and its finish: zinc-base alloys are more suitable for indoor use with moderate corrosive atmospheres; brass and other copper alloys are excellent materials for polishing and plating and their corrosion resistance is good (advantages worth weighing against rejection of these materials on the grounds of cost).

Barrel Tumbling—A further method of polishing, used especially for very large production on relatively small articles, is by barrel tumbling. In this process the articles are loaded into a many-sided barrel, which is rubber lined on the inside, and can be revolved about its axis or even eccentrically, preferably at variable speeds, with abrasive chips or polishing media and a prescribed volume of water with other chemicals. The time of treatment is usually several hours, so that the main consideration in design is that the parts should be sufficiently robust to withstand deformation by the weight of material being tumbled.

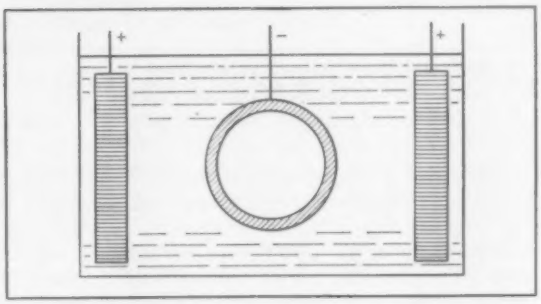
Screwed portions or other parts which are not to be polished may be protected with rubber or plastics caps or even held in fixtures in such a way that the abrasive media act only on the areas requiring polishing. Even large articles, machined to very fine limits and weighing many pounds, may now be finished by these special jigging methods.

Electro-chemical Polishing – Quite recently, chemical and electro-chemical polishing has been developed to a sufficiently high standard to merit its consideration in industrial finishing. Its use is as yet almost confined to

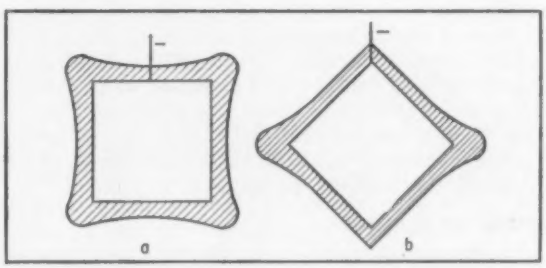
SEVERAL small plating barrels used for electroplating components for electrical and electronic equipment. (Courtesy Marconi Wireless Telegraph Co.)



1. "BAD" AND "GOOD" designs for polishing. The knurled, domed knob with recessed figures is easier to polish than the hexagonal, depressed knob with raised figuring.



2. MORE UNIFORM BUILD-UP occurs on the simpler shapes.



3. DEPOSIT on a simple cube can be varied by the method of suspension in the solution.

the treatment of stainless steel and aluminum, and, while there is little restriction on the design, the material used in manufacture must be very strictly controlled, as the chemical solutions must be carefully matched to the alloy in each case. It is unusual to find parts made from two even fairly similar alloys being treated in the same solution. The initial chemical equipment is costly, but production costs are fairly low, and even most intricate shapes can be polished to a degree virtually impossible by other means.

However, too much stress cannot be laid on the fact that the co-operation of the designer and the finisher should start the first conception of the idea, for especially in the case of aluminum and its alloys, some brightening treatments are only possible on a small range of alloys, even to "super-purity" material of 99.9 per cent aluminum, with a possibility of up to 1.5 per cent magnesium. As such alloys do not possess the desired physical properties required for many applications, their use is obviously limited.

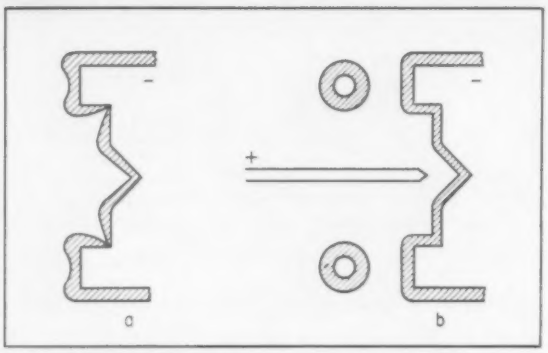
ELECTROPLATING

Turning now to those considerations of design and materials affecting electro-plating, the first general thought should be that of actual physical size. At the upper end, while local conditions vary, plating vats are usually not longer than 6 ft, with an effective width and depth of 2 ft. Very large articles should therefore be so designed that they may be split to fit such tanks and assembled after finishing. They should preferably be of such a weight that they may be comfortably handled by one man.

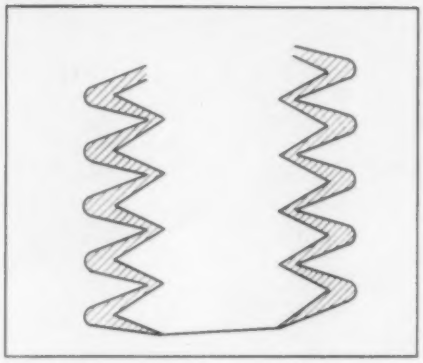
In the actual plating solution the most important factors are the strength of the solution, its temperature, acidity (or alkalinity), purity, degree of agitation and the correct proportion of its component parts. Metal anodes are suspended in the solution, connected to a positive dc supply, and these, as well as carrying current into the solution, usually replenish the metal content of the solution. The article to be plated is connected to the negative dc source and the correct voltage and current density for the size of that article in that particular solution are applied. The thickness or the total weight of metal deposited depends on the current passed and time.

Unfortunately, the metal is not deposited evenly except on the simplest of uniform shapes Fig. 2, but builds up more quickly on those areas nearer to the anode, and which thus have a higher current density. Thus promontories become more pronounced and recessed portions may receive no deposit at all.

In the design for best protection afforded by uniformly distributed metal, it is better to avoid sharp edges, reentrant angles (especially acute ones) and similar forms; luckily, these shapes coincide fairly well with requirements for polishing. The effects of this trouble are more serious with some metals than with other (the plater calls this "throwing power"), but the plater himself can influence the result to some extent. Fig. 3 shows how the deposit on a simple cube can be varied by the method of suspension in the solution, and Fig. 4 shows that, by using auxiliary anodes and cathodes, current can either be introduced into, or led away from, various points so that uniform plating is obtained. Obviously, such auxiliary anodes require very careful positioning. As most plating solutions are dense, opaque liquids, it is not possible



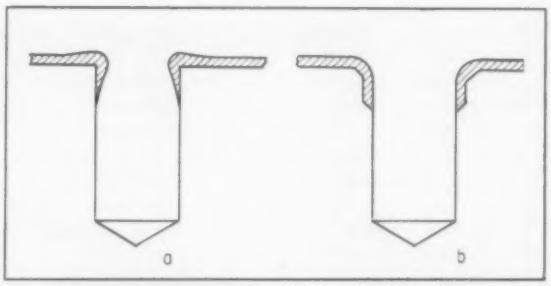
4. MORE UNIFORM plating can sometimes be achieved with auxiliary anodes and cathodes to control current at specific points. Such auxiliary anodes requires careful positioning.



5. SMALL SCREWS are usually plated in barrels, sometimes causing burrs on the threads, and resulting in uneven build-up of metal.

to watch what is happening while the plating is occurring, so that quite elaborate and rigid fixtures must be employed. Fig. 6 shows how a slight modification in design, admittedly requiring an extra operation, could be adopted with a threaded hole to provide sufficient clearance for normal plating build-up without interference; such forethought can save a great deal of trouble and recrimination later, especially in cases where trouble with 'fit" may be anticipated.

Screwed threads are particular cases where conventional plating methods very often cause trouble, as Fig. 5 shows. Small screws are usually plated in barrels, where the tumbling action of the barrel itself may even cause burrs on the threads, accentuating the trouble caused by the uneven build-up of metal; due allowance should be provided for this. Watch out for holes, too, Fig. 6.



6. SLIGHT MODIFICATION to a threaded hole can provide enough clearance for normal plating build-up without interference.

TYPES OF PLATING

In deciding on the nature and thickness of a protective finish for an article, the following brief details of the commoner processes available has been grouped into several parts according to the degree of protection afforded:

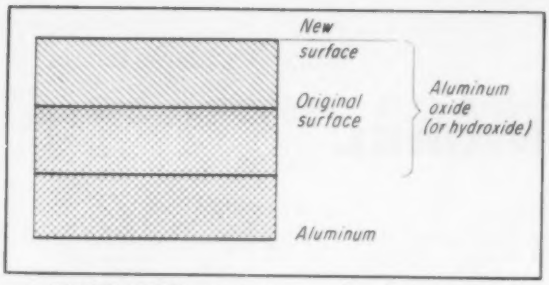
Oxide, Phosphate and Similar Chemical Films—These, in general, do not give much protection in themselves, but form a base or key for other films such as oil, lacquer or paint. They are quite thin (almost immeasurable) in themselves, but may be colored. Gunmetal black is a good example of this class.

Oxidised Finishes — These include oxidised coppers, brasses and bronzes, oxidised silver, etc. They are produced by plating usually cheaper metals with a thin film (about 0.0002 in.) of usually copper or silver, oxidising this chemically, relieving this oxidise film to produce the familiar pleasing effects and again coating with a clear lacquer. Here also the degree of protection is afforded by the choice of lacquer.

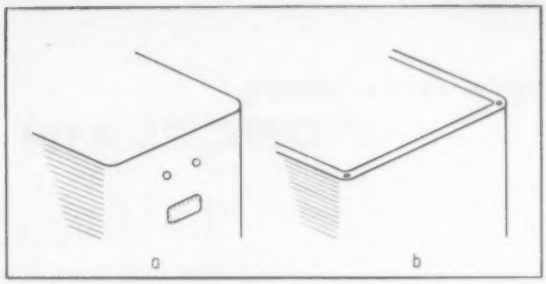
Bright Corrosion-resistant Finishes—For decorative finishes, bright chromium, nickel, alloy plating such as speculum, brass or bronze, are all eligible. If properly carried out, permanently bright deposits can give many years' protection in the environment for which they are intended. In bright chromium plate, the protection is given not by the chromium itself but by the undercoat of nickel or of copper and nickel. It is invariably the thickness of this undercoat and its freedom from porosity and microscopic cracks which determines the quality of the chromium, and in this, and other cases to be discussed later, specifications governing this aspect of quality should be laid down.

Where appearance of the deposit is not the primary consideration, deposits such as cadmium, zinc, tin and alloys, such as tin-zinc and tin-nickel, are used, although most of these metals can be deposited "bright" and are quite attractive. They can offer good resistance to corrosion in their particular environment with or without extra protection afforded by additional treatments such as passivating (which may leave a somewhat unpleasant khaki color) or painting. Little consideration in design is needed for such treatments, apart from a knowledge of some of the features of the metals concerned. For instance, cadmium should not be specified on parts likely to come into contact with foodstuffs; nickel or tin or even silver should be chosen in these cases. Springs and other parts made of steel with a tensile strength of over 45 tons per sq in. should be stress-relieved after plating. As the plater is not likely to know the tensile strength of any metal submitted for plating, special arrangements should be made to give him this information.

"Industrial" Plating—This includes heavy deposits of chromium, nickel, iron, silver, etc. Although the expression "hard chromium" is often used, this term is actually a misnomer, for the chromium is virtually of the same



7. PARENT METAL of aluminum surface is converted to an oxide, and an anodic film grown in thickness about equal to half the thickness of the film.



8. UNDESIRABLE FEATURES in painting: (a) Sharp edges of metal, punched holes and depression. (b) Similar cover modified: Edge turned over, drain holes provided.

hardness as that in bright chromium. The difference is essentially one of thickness, and, of course, "hard" chromium has no undercoat of nickel. It is usual in preparing components for a heavy build-up of metal, i.e., anything from 0.001 to 0.030 in. or more (e.g., for reclamation of valuable parts badly worn in service, salvaging of under-machined components, or to give certain new parts special wearing properties), to carefully grind the area to be plated in such a way as not to form microscopic cracks which are accentuated in plating, and to radius all angles. As it is only possible to deposit most metals smoothly up to about 0.003 in. thick, it is usual practice for thicknesses above this to plate at least 0.002 in. oversize and then carefully grind back to the correct size. Areas not requiring plating can, of course, be "stopped off" by the plater using an inert non-conductor such as wax, paint or plastics or rubber caps or tapes.

Precious Metal Plating—As well as for purely decorative application in the jewelery and allied trades, there is an increasing use of precious metals such as silver, gold, platinum, rhodium and indium in the electrical industry especially for the tarnish resistance offered by these metals in preserving electrical contacts. Mainly because of price and also because these films are fairly soft, the thickness is usually not more than about 0.0001 in.

TREATMENT OF ALUMINUM

Although by using special techniques aluminum can be plated with any other metal, the protection afforded is not yet as perfect as could be wished. This metal is protected mainly by anodizing, i.e., making the article the anode in either dilute chromic or sulfuric acid solutions. The oxide film thus produced, being integral with the parent metal, has many desirable properties. With sulfuric acid anodizing it is capable of absorbing organic dyes in the widest range of colors. When correctly sealed in pure boiling water, it is able to withstand a wide variety of corrosive conditions, provided that these are not strongly alkaline. Anodizing by the chromic acid method, whilst providing a film equal in corrosion-resistant properties, does not produce as attactive a film as the sulfuric acid method. The dark brown stain of chromic acid weeping from any minor surface imperfections does, however, make it useful as an inspection method, and the fact that any chromic acid trapped in welds or seams does not corrode the metal makes it the more favorable method of treating such fabrications. As no metal is deposited on to the aluminum, but rather the parent metal is converted to the oxide, an anodic film "grows" in thickness approximately equal to half the thickness of the film, as Fig. 7 shows. In normal cases, the film thickness will seldom reach 0.001 in., so that a micrometer reading before and after anodizing would record this same figure. The exception is in the case of hard anodizing, where, using refrigerated solutions kept down to about 0 deg. C., a thick, hard, brittle film up to 0.005 in. may be built up.

PROTECTING WITH PAINT

Depending mainly on the method of applying the paint, whether by brush, spray, electro-static spray, by flow coating or by dipping, some consideration at the design stage would help the product Fig. 8. Remember that it is practically impossible to apply paint of adequate thickness to the sheared edge of a sheet of metal. If it can be arranged, the raw edges should all be turned inwards. Holes, sharp depressions or promontories should also be avoided when dipping or flow coating is used. In these methods also it may even be necessary to include deliberately drain holes for excess paint.

SPECIFICATIONS

Almost every metal finisher would prefer to work up to a specification rather than down to a price, and many specifications are available. These may be either process specifications or product specifications. In the former case all the steps in the process are carefully set out; in the latter, provided that the end product complies, the methods of achieving those results are left to the individual. These covering items produced for a branch of the armed services, by large private firms for processes carried out in their own plants or by their sub-contractors and by independent organizations such as standards institutions, whose recommendations may be found valuable in many cases as a basis for reference in forming contract. Rigid inspection of a fixed percentage of samples should be insisted upon to insure maintenance of the agreed standard.

REFERENCE:
Designing for Simpler Metal Finishing Techniques by Adrian Walmsley, Chairman, N.W. Branch Institute of Metal Finishing. Published in Engineering Materials and Design, January '60, p. 18.

From: Porcelain Enamel Institute

quick facts about:

PORCELAIN ENAMEL

Physical, chemical, thermal and electrical properties tabulated for handy reference.

New industries and new product requirements are finding an increasing number of jobs for porcelain enamel. Combinations of base metal, undercoat, overcoat and processing produce scores of end results—one modern example is jet engine afterburner-shroud protection. In other products the multi-function properties of porcelain enamel meet different requirements such as low coefficient of friction and corrosion resistance in water lubricated bearings; high dielectric strength and corrosion resistance in rectifier components; abrasion resistance and low coefficient of friction in coal chutes.

The table below can act as a good general guide for the large number of porcelain enamels available.

REFERENCE:
Properties of Porcelain Enamel. Published by the Porcelain Enamel Institute, Washington 6, D.C.

APPEARANCE	
Hiding power	Opaque or clear as desired.
Gloss	"45°-45° specular-gloss test" varies from less than 1 to 85. (Polished black plate glass is about 55).
Texture	Smooth as ordinarily applied, but can be varied to suit requirements.
Color	Almost limitless variety; highly permanent and stain resisting.
Reflectance	Usually at least 75% for white enamel.
PHYSICAL	
Adherence	Excellent
Hardness	MOH 3.5-6 Knoop 150-550 Sward 100
Abrasion and wear resistance	Excellent
Coefficient of friction	Can be varied to suit from high (non-skid floors and blackboards) to low (water-lubricated bearings).
Impact resistance	Poor if base metal is deformed upon impact.
Specific gravity	2.4 to 3.9
Thickness range	1 mil to over ⅛ in.
Stiffening effect	Greater in compression. Adds stiffness equal to that of steel sheet ½ thickness of coating.
Viscosity	10,000 poises at firing temperature.
Elasticity	Young's modulus = 10^6 psi
Flexibility	Can withstand bend radii down to 6 in. for metal sheet, double-coated up to 0.01 in. enamel.
Imperviousness and resistance to absorption	Excellent
Freezing and thawing resistance	Excellent without moisture. In moist conditions some porcelain enamels will spall.
Coefficient of thermal expansion	From 5 to 15 × 10^{-6} in./in. °C at room temperature. Varies with temperature. Can be adjusted by changing mix.
Thermal conductivity	6 to 9 Btu/ft² hr (°F/in.)
CHEMICAL	
Acid resistance	Dependent upon pH value. Can be made to resist all except hydrofluoric acid.
Alkali resistance	Dependent upon type of alkali, not OH ion concentration. Excellent at room temperature. Poor with boiling concentrated caustic alkali.
Resistance to organic solvents, dyes, greases and oils	Excellent. Pay special attention to those that are acid forming.
Water resistance	Excellent at room temperature. More susceptible to continuously changing hot water and water above 160F.
Weathering	Acid resisting types best. Mat and non acid resisting porcelain enamels poor.
Salt spray resistance	Generally good but interpretation of tests results varies greatly.
Soil corrosion resistance	Same as acid and alkali resistance.
THERMAL	
High temperature	For most enamels 550F to 1100F. Special enamels offer protection to 2100F.
Emittance	0.95 at room temperature to 0.65 at 1500F.
Shock	Won't fail with 350F temperature changes. Specials to 800F.
ELECTRICAL	
Dielectric strength	250 to 1400 v/mil
Volume resistivity	10^{13} to 10^{16} ohm-cm at room temperature. Decreases with temperature rise.
Dielectric constant	6 to 12 at 400 cps, room temperature. Increases above 250F.
Dissipation Factor	1 to 2 at 400 cps, room temperature. Increases above 200F.

From: SPE Journal

9 PLASTIC FOAMS

A quick picture of how they are made, in what form they are supplied, and what their applications are.

C. R. DAVALL
New Product Market Development Dept.
Union Carbide Plastics Co.

PHENOLIC

Description: Thermoset cellular solid, density controlled by formulation, with densities of ½ lb/ft³ to over 10 lbs/ft³ possible.

Advantages: Ease of foaming in large scale industrial equipment, good heat resistance (under certain conditions up to 400 F) and can be made self-extinguishing without use of additives, has good dimensional stability and solvent resistance.

Disadvantages: Non-resilient, only fair mechanical strength, permeable, requires a seal at vapor barrier.

How Supplied: As high solids solution of resin in water.

How Prepared: Addition of catalyst results in foaming and curing of resin. Reaction provides heat required.

Uses: Thermal insulation and floral packaging applications.

POLYSTYRENE

Description: Closed-cell, density 1 to 10 lb/ft³.

Advantages: Low water-vapor transmission, toughness, semi-resilient.

Disadvantages: Flamability (though self-extinguishing grade is available), thermoplastic.

How Supplied: Prefoamed sheets, planks and boards, and as tiny granules which can be expanded and fused in molds into plank or other form.

How Prepared: Granules are expanded in molds by application of external heat.

Uses: Perimeter, pipe and freezer insulation, sandwich panel core, packaging, plaster base, decorative novelties.

VINYL

Description: Can be made either flexible or rigid, closed or open cell structure.

Advantages: Does not support combustion, can be heat-sealed to other materials thus reducing cost of trimming and adhesive operations, low water vapor transmission. Flexible type has high strength and toughness.

Disadvantages: Mechanical properties deteriorate above 140 F, resilience is reduced at temperatures below −20 F.

How Supplied: Sheets, slabs, molded cushions.

How Prepared: Most popular method utilizes Elastomer process, a mechanical technique for producing an open-celled flexible foam. An inert gas such as CO_2 is mixed with a vinyl plastisol at a pressure of 300 to 500 psi. When this mixture is released to normal atmospheric pressure through a nozzle or tube, it foams.

Uses: Rigid-insulation, cushioning, padding, and flotation.

URETHANE

Description: Can be made in either flexible or rigid state. Density controlled by amount of water and excess polyisocyanate used.

Advantages: Flexible urethane foam has good cushioning properties, tensile strength. Rigids can be made with very low K-factor.

Disadvantages: Some grades are flammable and/or have only fair dimensional stability.

How Supplied: 100% solids liquid materials.

How Prepared: Exothermic reaction of liquid components generates foam and hardens resultant polymer.

Uses: Flexible-comfort cushioning, rigid-thermal insulation, structural core material.

A "prefabricated" foam

A highly unusual variety of phenolic foam, which is not really a foam at all in the conventional sense of the word, is syntactic foam. The syntactics have the unique advantage of being a "prefabricated" foam because their cell structure does not depend on any chemical reaction but on premade hollow spheres of microscopic size filled with an inert gas. These spheres resemble soft red flour and are combined with either polyester or epoxy resin to form a putty-like material that cures with or without the application of heat to a strong, light-weight solid. The relative simplicity with which syntactic foam can be prepared has led to its use as a do-it-yourself material for minor repairs of rotted-out wood structures. Irregular areas which require a foamed-in-place type material not involving a chemical reaction are accessible to this type foam since it can be troweled or other wise handworked into difficult corners. This adaptability has also suggested syntactics for such applications as reinforced plastic boats.

PROPERTIES OF RIGID FOAMS

Foam	"K" Factor	Moisture vapor transmission	Percent closed cells	Flame propagation rate	Tensile modulus, psi	Tensile strength, psi	Tensile elongation	Change in strength after humidity aging	Friability
See notes below	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Molded vinyl	0.23	1.2	78	0	1900	73	9	....	0
Molded vinyl	0.23	0.9	84	0	2700	140	10	....	0
Polystyrene	0.26	1.8	78	8	2500	60	4	0	2%
Polyurethane	0.24	4.8	79	32	1500	60	5	−40	35%

Notes:
(1) "K" B.T.U.—in/hr per sq ft °F mean temperature 40°C temp. diff. 40°C
(2) Perm-inches
(3) Air displacement method
(4) At 100°C
(5) (6) (7) At 23°C
(8) Aged at 70°C and 80% relative humidity
(9) Tumbling friability (ASTM C-367)

* All foam samples tested were in the 2-lb./ft³ density range

POLYETHYLENE

High Density

Description: High density (about 35 lbs/ft³), semi-rigid foam.

Advantages: Electrical properties remain constant at high frequencies and material permits a considerable reduction in cable size and weight. Has good moisture resistance and economical production on conventional extrusion equipment.

Disadvantages: High density, flammable.

How Supplied: As extrusion compound.

How Prepared: Extruded.

Uses: Cable insulation.

Low Density

Description: Low density (2.0-2.2 lbs/ft³), semi-resilient foam.

Advantages: Low water absorption and moisture vapor transmission, resilient, good chemical resistance, odorless.

Disadvantages: Thermoplastic, flammable.

How Supplied: Slabs and cylinders of foam.

Uses: Flotation, packaging and gasketing products. Thermal insulation.

EPOXY

Description: Rigid, closed cell, thermoset foam.

Advantages: Tough, good electrical properties, good adhesion, and ability to be foamed-in-place.

Disadvantages: High price.

How Supplied: Prefoamed blocks or foamable liquids.

How Prepared: Mixture of two reactive, liquid components which generated foaming action and heat required to harden foam.

Uses: Potting and encapsulation of electrical components and tool checking fixtures or other tool and die parts for which their specific properties make them suitable.

SILICONE

Description: Open cell, thermoset rigid foam.

Advantages: Outstanding high-temperature resistance—useful at 500 to 700 F.

Disadvantages: High cost.

How Supplied: Foamable powders.

How Prepared: Application of external heat results in foaming and cure of resin.

Uses: Only where outstanding high temperature resistance is needed or outstanding electrical properties are needed.

CELLULOSE ACETATE

Description: Closed cell, rigid foam.

Advantages: Considerable toughness, easily machined.

Disadvantages: Low softening point, comparatively high cost.

How Supplied: Prefoamed boards and rods.

How Prepared: Extrusion of resin melt.

Uses: Structural core material, flotation devices, packaging material.

REFERENCE:
Plastic Foams—A Directory by C. R. Davall, Union Carbide Plastics Co, New York, New York. Published in SPE Journal, November '59, p. 955.

From: Company Bulletin

Lignum Vitae... its properties and applications

Mechanical, physical, electrical and chemical properties of this unusual engineering material, together with 32 of its practical applications.

PRODUCTS MADE FROM LIGNUM VITAE	
Block bearings	Engine mounts
Hanger bearings	Rocket-fuel cores
Roll neck bearings	Valve plugs
Ships bearings	Chemical processing equipment
Segment bearings	Cable dressers
Straight bushings	Steady rests
Flanged bushings	Wheels
Split bushings	Balls—all types
Slides	Graining balls
Wire guides	Stencil blocks
Guides, all types	Rings
Marine supplies	Tumbling material
Mallets & mauls	Handles
Non-contaminating utensils	Police clubs
Pulleys	Muddlers
Rollers	Leather-working tools

REFERENCE:
Lignum Vitae, One of the Most Unique & Versatile Engineering Materials. Published by Lignum-Vitae Products Corp, Jersey City, N.J.

Extreme hardness combined with self-lubricating properties are the chief characteristics of lignum vitae. These account for one of its chief applications—bearing material. There are, however, many other engineering applications; it has even found its place in the space age—as rocket-fuel cores.

The best quality lignum vitae comes from guayacum trees, which grow mostly in Cuba, Haiti, Yucatan, Dominican Republic, the west coast of Mexico, Central America and Paraguay. Finely twisted grain is one feature that contributes to its tough properties. The wood contains 3% lubricating resin, which is held in pores throughout the wood.

Since the findings tabulated here are statistical quantities it is advisable that the material be always tested in a model before firming a design. Much practical experience has shown that:

- Under certain conditions the bearing surfaces of lignum vitae become glazed after usage, this causes a lower coefficient of friction, which is reflected in lower power consumption.
- Lignum vitae can be used under relatively heavy loads without requiring lubrication.
- Lignum vitae's natural tenacity and durability is due to its interwoven fiber structure and homogenity.
- Lignum vitae is non-contaminating to foods and is ideally suited for applications where this quality is desirable.
- Lignum vitae has excellent relative resistance to boiling water and chemicals.
- Due to the self-lubricating resin that grows naturally in lignum vitae and impregnates every pore, it is impossible for the lubricating resin to dry out through capillary action.

Lignum vitae is available in rods, blocks, boards, logs, and rough-machined or finished bearing-blocks.

TABLE I—Strength and Abrasion Resistance

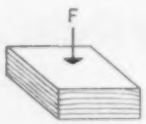
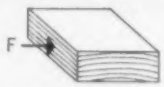
(TESTS CONDUCTED BY TIMBER ENGINEERING CO. U. S. TESTING CO., AND CERTAIN U. S. GOVERNMENT AGENCIES)	DIRECTION OF FORCE	
		
PROPERTY	RADIAL	TANGENTIAL
Compression	10360 psi	9930 psi
Hardness	22180 psi	19770 psi
Toughness	195.5 in.-lb	135.0 in-lb
Bending (rupture mod.)	20100 psi	16800 psi
Abrasion resistance (dry)	0.0102 = 100%	———
Abrasion resistance 6 days soak—8 hours boiled	0.0161 = 63%	———
Abrasion resistance 7 days water soaked	0.0110 = 93%	———
Abrasion resistance sub-zero temp.	0.0101 = 101%	———

TABLE II—Coefficient of Friction for Lignum Vitae and Comparable Bearing Materials

MATERIAL	DIRECTION OF MOTION	KINETIC—DRY	KINETIC—WATER IMMERSED
Lignum vitae	Parallel to cross section	0.160	0.094
Lignum vitae	Perpendicular to grain	0.158	0.192
Lignum vitae	Parallel to grain	0.158	0.253
Impregnated maple	Parallel to cross section	0.125	0.206
Impregnated maple	Perpendicular to grain	0.123	0.235
Impregnated maple	Parallel to grain	0.123	0.256
Nylon	———	0.160	0.141
Parock (Rubber)	———	0.229	0.193
Micarta	Parallel to laminations	0.225	0.318

Coefficient-of-friction tests were conducted using different samples of each material in contact with a cold-rolled steel plate. These results represent an average of the various tests taken in each specific grouping.

TABLE III—Swelling of Lignum Vitae Immersed in Water

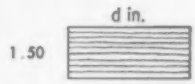
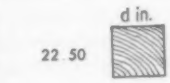
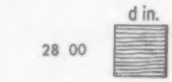
SIZE, d IN.	NUMBER OF DAYS TO REACH 25% OF MAXIMUM SWELLING	NUMBER OF DAYS TO REACH 50% OF MAXIMUM SWELLING	NUMBER OF DAYS TO REACH 75% OF MAXIMUM SWELLING	NUMBER OF DAYS TO REACH 100% OF MAXIMUM SWELLING	MAXIMUM DIMENSIONAL CHANGE IN MILS PER INCH OF DIMENSION d, IN.
¼	1.00	2.75	6.25	16.00	
½	2.50	5.50	12.50	32.00	
¾	3.50	8.50	18.50	48.00	
1	4.50	11.50	24.75	64.00	
1½	6.75	17.00	37.25	96.00	
1¾	8.00	20.00	43.50	112.00	
2	8.75	23.00	49.50	128.00	
2½	11.00	28.50	62.00	160.00	
3	12.75	34.00	74.50	192.00	

TABLE IV—Chemical Resistance of Lignum Vitae with Different Reagents

REAGENT	WEIGHT CHANGE, %	LENGTH CHANGE, %	WIDTH CHANGE, %	THICKNESS CHANGE, %
Sodium hydroxide (10%)	+7.50	+0.09	+1.26	+4.46
Toluene	−1.39	−0.06	−0.65	−0.40
Sodium chloride (10%)	+2.29	−0.10	+0.92	+0.80
Ethyl alcohol (50%)	+0.89	−0.02	−0.38	+1.00
Heptane	−1.15	−0.04	−0.47	−0.30
Sulphuric acid (3%)	+3.99	−0.09	+1.68	+1.59
Sodium hydroxide (1%)	+3.89	+0.10	+1.52	+2.05
Acetic acid (5%)	+3.14	−0.07	+1.46	+1.32
Ethyl acetate	−1.29	−0.01	−0.48	−0.27
Ethyl alcohol (95%)	−2.01	−0.03	−0.01	0.00
Acetone	−3.35	−0.09	+0.33	+1.11
Carbon tetrachloride	−1.54	−0.11	−0.47	−0.66
Sulphuric acid (30%)	+0.72	−0.05	−0.27	−0.20
Water	+5.30	+0.19	+2.36	+1.68

From: Plating

PLATING NICKEL on Aluminum Alloys

Formula, plating procedures, adhesion and corrosion-test results for a recently developed process.

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Following earlier work on electroplating on aluminum from strongly acid solutions, this new process for nickel plating aluminum from sulfate-fluoborate-chloride baths has been developed. Adhesion values of about 5000 psi in shear can be obtained, and still better adhesion results from the use of proper heat treatment. The process eliminates zincate or other pretreatments for all aluminum alloys tested, and appears to have industrial potentialities for general electroplating and electroforming operations with nickel. Here is a rundown of the basics involved.

PLATING FORMULA

The solution composition is as follows:

	Preferred	Allowable
Nickel sulfate crystals	200 g	100-400 g
Nickel fluoborate crystals	66 g	132-33 g
Nickel chloride crystals	1 g	¼-1 g
Boric acid	20 g	10-40 g
Water to make	1 liter	1 liter
pH	1.0	0.9-1.5
Operating temperature	60C	50-70C

The nickel sulfate and chloride crystals were reagent grade hexahydrates. Nickel fluoborate was a purified crystal. Total nickel concentration in the preferred bath was 68 g/l. pH may be controlled with sulfuric acid or nickel carbonate.

The functions of the various components appear to be as follows:

The combination of nickel sulfate and fluoborate furnishes the necessary nickel content and conducting ion species. The principal limitations on concentrations are imposed by external factors—the maximum amount of either nickel compound cannot be used with the maximum of the other because of solubility limitations, and too low a concentration of nickel salts could only support undesirably low current densities. The concentration of chloride has to be maintained precisely when aluminum is to be plated to control the aggressiveness of the solution toward aluminum and its oxide film. Boric acid promotes maintenance of a stable bath pH in operation.

Broadly similar solutions outside the preferred range can still be employed, particularly if the chemicals used are exceptionally pure. Fluosilicates of sufficient purity may apparently replace fluoborates, but normal purity material can cause trouble. In any event, the solution soon gels and is of no further use. A variety of other halides may replace nickel chloride. The preferred solution is also less satisfactory if operated at pH 4; here the usual pretreatment schemes for plating on aluminum must be resorted to for good adhesion.

Control of Impurities

Purity of raw materials for this process was found to be important and deionized or distilled water should be used for makeup. Commercial grades of nickel fluoborate and sulfate normally contain sufficient chlorides and copper to require special treatment. The chlorides may be removed by precipitation with silver sulfate, or determined analytically so that due allowance can be made when adding nickel chloride crystals. Copper, and other heavy metals, may be removed by prolonged electrolysis at low current density or by precipitation on scrap nickel. The high sensitivity of the bath to copper makes it wise to nickel plate all copper bus, etc. in the vicinity of the plating tank.

Nitrates, though normally not present in the chemicals used, disrupt the operation of the bath and hence should be avoided. Prolonged electrolysis at low current density will rectify nitrate contaminated solutions. Contamination by organics is obectionable as in normal nickel plating practice, and addition agents such as saccharin and sodium lauryl sulfate appear to have the expected effects on plating characteristics. Treatment with activated charcoal can remove unwanted organic contaminants; use of cellulose base rather than mineral filter aids seems wise in the filtration step.

PLATING PROCEDURE

The only necessary pretreatment is immersion or cathodic cleaning for not more than two minutes in a solution of 3% each of trisodium phosphate and sodium carbonate at 60C. Normally, the aluminum alloy is first degreased in a vapor degreaser; then treated in the mild alkaline cleaner. At this stage there is some reaction between the aluminum alloy and the alkaline cleaner, and the

object is to have the maximum reaction with the cleaner consistent with a smut free surface. If smut forms remove it with a dip in dilute sulfuric acid or by brushing. In the case of the copper-containing alloys, smut formed rather rapidly in the alkaline cleaner. Here, it is preferable to return the work a second time to the mild cleaner, but only for about ten seconds, following the initial cleaning and sulfuric acid treatment. Following rinsing, the work is ready for plating.

The initial strike on aluminum alloys is made with the preferred composition given above at 30 to 40 amp/ft² at 60C for about one minute. Thereafter the current density can be increased to a limit set by cell agitation etc. During the striking operation, a minor amount of gassing may occur. It is not possible to demonstrate a cathode efficiency significantly different from 100% for deposits of 0.3 mil. Anode efficiency is also close to 100%.

The plating solution gives a good direct nickel deposit on commercially pure aluminum, 5052, 6061, 7075 and a number of special purpose experimental alloys. Favorable initial results on a casting alloy containing 13% silicon have also been reported.

Other Materials

For general plating, or for building up deposits on aluminum after the strike has been applied, very rapid deposition is possible. The highest value consistent with sound plating on simple objects was found to be 750 amp/ft², and this appears to be a function of solution agitation, work piece conductivity and available voltage rather than an inherent limit of the solution. This current density approaches the order of the maximum rate of deposition reported for any nickel plating solution, and is likely to allow practical electroforming. The bath is stable in extended use.

Direct plating is practical on zinc, mild steel, stainless steel and brass, following appropriate cleaning operations only and without requiring an activation step for stainless steel. Titanium doesn't accept a satisfactory direct plate. It is interesting to note that the strongly acid solution is compatible with both zinc and mild steel for direct plating. Plated articles of the various materials showed good resistance to atmospheric corrosion in the laboratory at a distance of 600 feet from Halifax Harbour after a twelve-month interval. Limited testing of various nickel plated steel articles plated with one mil of nickel for shipboard use has also been performed. This indicates that this form of nickel plating has remarkable versatility.

ADHESION OF PLATING

Only in the case of nickel plating on aluminum were quantitative adhesion studies made. Plating on the other metals cited appeared to be of good quality so far as could be ascertained by qualitative tests and by its corrosion behavior. Typical samples for adhesion testing had nickel plates 0.3 mil thick.

The nickel plating on aluminum, in the as-plated condition consistently showed adhesion of at least 4000 to 5000 psi in shear on soldered lap joints. Because of the proximity of the test results to the ultimate properties of solder, studies were undertaken to devise a test of more extended range. The simplest form of improved test used a soft-soldered lap-joint tested while refrigerated in a dry ice-acetone mixture. The range of this test was up to over 10,000 psi in practice, the usual limit being not over 12,000 psi.

This improved test confirmed that the adhesion range of plated stock is at least 4000 to 5000 psi. It also enabled the effects of heat treating operations to be assessed. The most effective heat treatment cycle appeared to be a ten-minute soak at 500C followed by quenching. Metallographic examination of heat-treated plated stock enable the thin diffusion layer to be identified as Ni_3Al_2. Adhesion of heat treated stock exceeded the capability of the test, showing about 10,000 psi minimum in shear typically. Qualitative tests based on bending do not disclose adhesion deficiencies in as-plated or heat treated samples.

CORROSION TESTS

Samples of nickel plating 1 mil thick on 2S aluminum alloy, and on alloys developed for corrosion resistance to high temperature water, were tested in pure water at 350C under static conditions and in water flowing at 20 ft/sec, the bulk of the testing being performed by Atomic Energy of Canada Limited, at Chalk River, Ontario. The plated aluminum showed significant improvement in corrosion resistance compared with that of unplated material. Porosity in the plating, or possibly pitting corrosion, seemed to be responsible for failure. In most, though not all cases, there was rapid lateral penetration at the nickel-aluminum interface once a pore reached there. Thus, although this form of plating had good characteristics, it could not be chosen over electroless plating on account of the freedom from porosity of the latter.

LIMITATION

The nickel plating process described here has shown considerable versatility on a laboratory scale for a wider range of applications than originally envisaged. It is unique as a method for plating on high-silicon aluminum alloys. It is remarkable as a method for plating directly on aluminum alloys in that the initial strike and later high speed deposition can be made from the same solution without modification, as well as permitting direct plating on a variety of other materials, including mild steel and stainless steel. The chief limitation of the process seems to be the requirement for an unusually precise control of chloride concentration. Pilot plant evaluation is now under way by a licensee of the process to determine whether the laboratory scale promise can be duplicated in larger equipment.

REFERENCE:

Novel Process for Plating Nickel on Aluminum Alloys by James T. N. Atkinson, Department of National Defence, Defence Research Board, Naval Research Establishment, Dartmouth, Nova Scotia. Published in Plating, May 1960, p. 509-510.

This process described here is the subject of Canadian Patent 590,840, issued Jan 19, 1960. Assigned to Canadian Patents and Development Limited, a Canadian government corporation, it is available for license.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(C-1) **Sealant**—Brochure, 8 pp. Gives properties, applications and instructions for use of compounds for metal to metal sealing and locking. American Sealants Co, 121 Woodbine St, Hartford, Conn.

(C-2) **Plastic Extrusions**—Brochure, 8 pp. Relates case histories of design problems which have been solved by using custom plastic extrusions. Crane Plastics, Inc, 506 Hutton Pl, Columbus 15, Ohio.

(C-3) **Plastic Moldings**—Catalog, 12 pp. Discusses compression, injection and transfer molding with nine different base-resin combinations. Continental-Diamond Fibre Corp, Newark, Del.

(C-4) **Nylon Extrusions**—Catalog, 8 pp. Gives properties and sizes of nylon tubing, pipe, rod and strip. Also fabrication data. Danielson Mfg Co, Danielson, Conn.

(C-5) **Rigid Urethane Foams**—Brochure, 4 pp. Gives formulation codes, pouring and mixing instructions for poured-in-place foams. Dayco Corp, Dayton, Ohio.

(C-6) **Urethane Elastomer**—Brochure, 4 pp. Compares properties to other elastomers. Suggests uses such as bearings, gears, packing, others. Dayco Corp, Dayton, Ohio.

(C-7) **Plastic Vacuum Hose**—Brochure, 8 pp. Describes types, kinds and construction of flexible hose for medical equipment, industrial and farm machinery. The Dayton Plastics Co, Div of Dayco Corp, Dayton, Ohio.

(C-8) **Thermoplastics**—Bulletin, 6 pp. Lists uses and available forms. Includes table of properties for six different plastics. Westlake Plastics Co, Lenni Rd, Lenni Mills, Pa.

(C-9) **Reinforced Plastic**—Brochure, 4 pp. Presents properties, suggested applications of TFE fluorocarbon and the standard and nonstandard shapes available. Dixon Corp, 19 Burnside St, Bristol, RI.

(C-10) **TFE Fluorocarbon Resins**—Bulletin 8 pp. Monthly technical information bulletin published by the producer. E I du Pont de Nemours & Co, 10th & Market Sts, Wilmington 98, Del.

(C-11) **Cast Rubber**—Brochure, 8 pp. Describes properties, advantages and uses of cast liquid urethane. Acushnet Process Co, Box 916, New Bedford, Mass.

(C-12) **Felt**—Catalog, 24 pp. Describes properties and special treatments. Gives design pointers. Includes lubrication seals, gaskets. The Felters Co, 210 South St, Boston.

(C-13) **Laminated Plastic**—Brochure, 4 pp. Provides table of chemical, electrical and mechanical properties of different grades. Formica Corp, Subs of American Cyanamid Co, 4516 Spring Grove Ave, Cincinnati 32.

(C-14) **Tooling Plastic**—Brochure, 4 pp. Describes a laminated plastic for dies, and wear resisting and structural applications. Formica Corp, Subs for American Cyanamid Co, 4516 Spring Grove Ave, Cincinnati 32.

(C-15) **Industrial Plastics**—Catalog, 100 pp. Gives properties, uses, shapes of laminates and molding plastics with many different base or filler materials and resins. Formica Corp, Subs of American Cyanamid Co, 4516 Spring Grove Ave, Cincinnati 32.

(C-16) **Plastic Shapes and Parts**—Catalog, 16 pp. Furnishes plastic properties and dimensions of shapes such as rod, sheet, slab, tubing, tape. Garlock, Inc, Palmyra, NY.

(C-17) **Rubber Parts**—Brochure, 8 pp. Describes facilities for compounding, molding, lathe-cutting and bonding natural, synthetic and silicone rubber. Goshen Rubber Co, Inc, 2090 S 10 St, Goshen, Ind.

(C-18) **Glass Reinforced Plastic**—Brochure, 24 pp. Gives mechanical, electrical and chemical properties plus design tips. Also shows each step in production process of molded shapes. G B Lewis Co, Watertown, Wisc.

(C-19) **Lignum Vitae**—Data folder, 28 pp. Gives properties and uses of lignum vitae, the hardest wood known, as a self-lubricating bearing material. Lists sizes of bearings, bushings and shapes. Lignum-Vitae Products Corp, 96 Boyd Ave, Jersey City 4, NJ.

(C-20) **Vinyl Finish**—Brochure, 8 pp. Gives material properties, describes various surface textures and suggests possible uses on a laminated construction. The Masland Duraleather Co, Industrial Products Div, Amber & Willard Sts, Philadelphia.

(C-21) **Glass Reinforced Plastics**—Brochure, 32 pp. Describes, illustrates production methods, design considerations. Presents physical, electrical and chemical properties of materials. Molded Fiber Glass Co, 4423 Benefit Ave, Ashtabula, Ohio.

(C-22) **Silicone Rubber and Fluorocarbon Compounds**—Bulletin, 6 pp. Lists properties of compounds to meet requirements such as high temperature, low temperature, oil resistance and others. Moxness Products, Inc, 1914 Indiana St, Racine, Wisc.

(C-23) **Powdered Polyethylene**—Bulletin, 8 pp. Describes uses of powdered resin as coating and for large hollow moldings. US Industrial Chemical Co, Div of National Distillers & Chemical Corp 99 Park Ave, NYC 16.

(C-24) **Plastics**—Catalog, 8 pp. Presents physical, electrical and chemical data on resin-rubber compounds, polyester resins and polyvinyl chloride resins. Naugatuck Chemical Div, US Rubber Co, Naugatuck, Conn.

(C-25) **Ceramic Coatings**—Bulletin, 10 pp. Describes spray-coating process. Lists properties of materials for protection from high temperature, abrasion, corrosion and erosion. Norton Co, 1 New Bond St, Worcester, Mass.

(C-26) **Vinyl Sheet**—Brochure, 12 pp. Supplies samples of flexible sheet. Outlines case histories of product uses. Polo Plastics Co, 1718 N First St, Milwaukee 12.

(C-27) **Plastics**—Brochure, 8 pp. Compares fitness of different types for a number of fabrication methods. Union Carbide Plastics Co, Div of Union Carbide Corp, 270 Park Ave, NYC 17.

(C-28) **Coated Fabrics**—Catalog, 8 pp. Gives specifications and characteristics of synthetic and natural rubber coated nylon, cotton or glass cloth. Reeves Bros, Inc, Vulcan Rubber Products Div, 1071 Ave of the Americas, NYC 18.

(C-29) **Felt**—Brochure, 4 pp. Supplies eighteen samples, table of properties and suggested uses. Western Felt Work, 4021-4139 Ogden Ave, Chicago 23.

(C-30) **Treated Felt**—Brochure, 4 pp. Supplies twelve samples of coated or impregnated felt with special capabilities. Western Felt Works, 4021-4139 Ogden Ave, Chicago 23.

(C-31) **Synthetic Rubber Products**—Brochure, 16 pp. Describes range of materials and end products. Outlines materials characteristics. Includes dimensional data on lathe cut dynamic and static seals. Acadia Synthetic Products, 4035-4117 Ogden Ave, Chicago 23.

(C-32) **Silicone Rubber**—Brochure, 10 pp. Contains tables of physical, electrical and chemical properties. Illustrates applications. Acushnet Process Co, Box 916, New Bedford, Mass.

(C-33) **Plastics**—Bulletin 8 pp. Tables give properties of thermosetting molding compounds, fire-retardant polyester resins and phenolic resins for molding and laminating. Durez Plastics Div, Hooker Chemical Corp, 1514 Walck Rd, N Tonawanda, NY.

(C-34) **Metal to Rubber Bonding**—Brochure, 8 pp. Describes process, compounds, design considerations, uses. Acushnet Process Co, Box 916, New Bedford, Mass.

(C-35) **Rubber Products**—Brochure, 33 pp. Gives general description of facilities and products. Includes tables and discussions of properties of natural and synthetic rubbers. Acushnet Process Co, Box 916, New Bedford, Mass.

(C-36) **Plastic Pipe**—Bulletin, 16 pp. Curves show such data as head loss, deflection, working pressures, and more. Gives dimensions of pipe and fittings, discusses properties. Amercoat Corp, 4809 Firestone, South Gate, Cal.

(C-37) **Plastic Tank Lining**—Brochure, 6 pp. Plastic sheet protects steel and concrete from corrosion. Properties, including chemical resistance, are discussed. Amercoat Corp, 4809 Firestone Blvd, South Gate, Cal.

(C-38) **Large Polyolefin Moldings**—Brochure, 4 pp. Gives rod and block sizes of three different types of polyolefins. One use is neutron shielding. American Agile Corp, Box 168, Bedford, Ohio.

(C-39) **Plastic Extrusions**—Brochure, 4 pp. Describes facilities for making flexible and rigid extrusions. Contains table of plastics properties. William Brand-Rex Div, American Enka Corp, 31 Sudbury Rd, Concord, Mass.

(C-40) **Flat Glass**—Brochure, 8 pp. Show properties and uses of special glasses. Includes safety, heat resistant, corrosion resistant and other glasses. American-Saint Gobain Corp, 625 Madison Ave, NYC.

(C-41) **Extruded Plastics**—Brochure, 12 pp. Lists sizes and some shapes and materials available. Illustrates applications. Anchor Plastics Co, Inc, 36-36 36th St, NYC 6.

(C-42) **Rubber Products**—Catalog, 158 pp. Shows almost everything imaginable in small molded or extruded rubber parts, as well as sheet, tube, sponge. From adapter bushings to weatherstrip. Atlantic India Rubber Works, Inc, 571 W Polk St, Chicago 7.

(C-43) **Vinyl-metal Laminates**—Brochure, 7 pp. Describes laminating process and colors, textures, possible uses. Arvin Industries, Inc, 13 St, Columbus, Ind.

(C-44) **Plastic Shims**—Brochure, 7 pp. Presents properties of shim stock, dimensions of standard sizes of shims. The Artus Corp, 201 S Dean St, Englewood, NJ.

(C-45) **Rubber and Plastics**—Brochure, 12 pp. Explains scope of services and materials in molding, encapsulation, bonding, formulation and testing. Bacon Industries, Inc, 192 Pleasant St, Watertown 72, Mass.

(C-46) **Liquid Polyvinyls**—Brochure, 15 pp. Gives properties and uses as a coating or molding compound. Bee Chemical Co, 12933 S Stony Is Ave, Chicago.

(C-47) **Vacuum Metallizing Coatings**—Catalog, 45 pp. Describes properties and methods of applying top and back up coatings on a variety of base materials. Bee Chemical Co, 12933 S Stony Is Ave, Chicago 33.

(C-48) **Coatings**—Brochure, 34 pp. Presents properties, application methods and uses of coatings for metal, plastics, wood, glass. Bee Chemical Co, 12933 S Stony Is. Ave, Chicago 33.

(C-49) **Strippable and Permanent Coating**—Catalog, 64 pp. Plastic coatings which spray on are for military and industrial packaging and for during metal fabrication. Permanent coatings are for weather and corrosion protection. Better Finishes & Coatings, Inc, 268 Doremus Ave, Newark 5, NJ.

(C-50) **Plastics Properties**—Bulletin, 6 pp. Compares properties of different plastic families with each other and with other materials. Cadillac Plastic & Chemical Co, 15111 Second Blvd, Detroit 3.

(C-51) **Standard Plastic Shapes**—Catalog, 64 pp. Lists sizes and properties of sheet, rod and other shapes made from acetate through vinyl. Cadillac Plastic & Chemical Co, 15111 Second Blvd, Detroit 3.

(C-52) **Plastic Resins and Glass Fiber**—Catalog, 16 pp. Lists resins, and glass fiber in such forms as mat, cloth, tape, others. Cadillac Plastic & Chemical Co, 15111 Second Blvd, Detroit 3.

(C-53) **Teflon Shapes**—Catalog, 8 pp. Gives teflon properties and sizes of sheets, tape, rods, other shapes. Cadillac Plastic & Chemical Co, 15111 Second Blvd, Detroit 3.

(C-54) **Nylon Shapes**—Brochure, 8 pp. Gives nylon properties and sizes of rod, sheet and other shapes. Cadillac Plastic & Chemical Co, 15111 Second Blvd, Detroit 3.

(C-55) **Refractories**—Two brochures, 16 pp. Present specific cases of refractory use in equipment designs. The Carborundum Co, Refractories Div, Perth Amboy, NJ.

(C-56) **Grinding Cemented Carbides**—Brochure, 22 pp. Discusses techniques of grinding cemented carbides with green grit and diamond wheels. Topics included are: coolants, chip-breaking grinding, feeds, speeds, wet vs. dry grinding and others. Bonded Abrasives Div, The Carborundum Co, Niagara Falls, N. Y.

(C-57) **Molded Teflon**—Brochure, 4 pp. Lists dimensions, weights and properties of molded teflon tube, sheet and rod. Chemo Products, Inc, 100 Pulaski St, W Warwick, RI.

(C-58) **Rubber and Leather Products and Seals**—Catalog, 15 pp. Discusses wide range of materials and products from ceramic face seals to leather transmission belts. Chicago-Allis Mfg Corp, 113 N Green St, Chicago 7.

(C-59) **Teflon Products**—Catalog, 30 pp. Contains properties, prices of tube, sheet, rod o-ring, gaskets, couplings, tape, others. Chicago Gasket Co, 1271 W North Ave, Chicago.

(C-60) **Molded Plastics**—Brochures, 8 pp. Describes company capabilities, stock knobs, properties and uses of sheet and film. Chicago Molded Products Corp, 1020 N Kolmar, Chicago.

(C-61) **Epoxy Resins**—Brochure, 8 pp. Describes properties and applications as finishes, adhesives, tooling, laminates and others. Ciba Products Corp, Fair Lawn, NJ.

(C-62) **Epoxy Resins**—Brochure, 8 pp. Charts properties, structural, coating and other uses of 17 resins. CIBA Products Corp, Fair Lawn, NJ.

(C-63) **Creped Kraft Paper**—Brochure, 8 pp. Explains manufacturing process, properties and uses as plastics lamination reinforcement, imitation chamois, furniture components. Cincinnati Industries, Inc, Cincinnati 15.

(C-64) **Adhesive Plastic Coating**—Brochure, 4 pp. Contains samples of metallic finish textured polyester with adhesive backing. Coating Products, Inc, 101 W Forest Ave, Englewood, NJ.

(C-65) **Silicone Rubber Products**—Data Sheets, 18 pp. Presents properties, specifications of silicone rubber sheet, sponge, cements, conductive gasketing, tape plus plastic and glass tape. The Connecticut Hard Rubber Co, 407 East St, New Haven, Conn.

continued

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FELT GREATLY REDUCES GLAZING COSTS

over conventional brushing. Fine china manufacturer uses special Felters DuFelt Polishing Belt to reduce glazing costs. Felt coarseness and density can be varied for most effective polishing of metal, glass and ceramics. Can also be coated with abrasives.

FELT ADHESIVE TAPES AND PADS

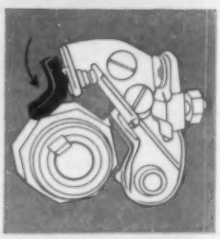
are the most inexpensive material for sealing, padding and cushioning. Felt strips seal out dust, dirt, wind, fumes, moisture, and eliminate squeaks and rattles.

FELT AS A LOW COST FRICTION MATERIAL

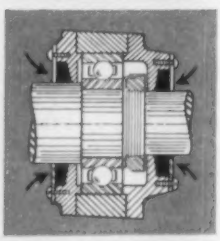
Used as a braking or friction device, sometimes combined as a seal or washer. High coefficient of friction and extra density provide foolproof clutching and tension action at low cost, like the Lever Puller shown at left.

To get the most out of Felt, send for the Felters Design Book — a complete digest on properties and applications. Write, today.

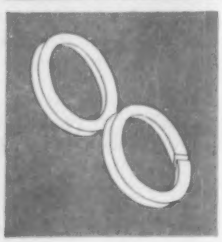
DuFelt is a laminated combination of Felters' felt and Hycar; and is recommended for sealing of lighter oils when no head exists. Seals and lubricates at the same time; and offers improvements over other materials.



Felt is an ideal wicking and lubricating material which can be designed into special assemblies like this distributor cam shown here. Lubrication is constant, wear reduced, and felt can be shaped to cover all required areas.



Lifetime bearing lubrication is now possible by selection of correct SAE grade, and designing into sealed bearing. Felt filters out contamination and works as combined reservoir and wick, directing oil flow to required areas.



Mechanical felt seals permit a close seal without undue pressure. Felt can be waterproofed and provides superior grease and oil retaining and dust, dirt and grit exclusion.

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THE FELTERS COMPANY

259 SOUTH STREET, BOSTON 11, MASSACHUSETTS

Pioneer Producers of Felt and Synthetic Non-Woven Fabrics

FCO-25

working with

Du Pont Zytel®

nylon resins

one of Du Pont's versatile engineering materials

Turbine fan of ZYTEL® makes possible radical design

A difficult design problem in Sunbeam's new de luxe vacuum-cleaner line involved the turbine brush sweeper accessory. The turbine brush combines the advantage of a power-driven brush, previously found only on uprights, with the power and flexibility of a tank-type cleaner. This brush is powered by a unique one-piece fan wheel made up of 54 curved blades, spaced to allow the intake of metallic objects such as paper clips, hairpins and the like.

For satisfactory operation of this turbine wheel, an exceptional material was required—one with high strength in thin sections, resilience, and resistance to metallic impact. The material had to be intricately molded to close tolerances in an economical one-piece molding. In addition, lightness of weight, abrasion resistance, and good bearing properties were needed. The solution: a wheel molded of Du Pont ZYTEL nylon resin, which fulfilled all these requirements. The successful design of this component, molded by Chicago Molded Products Corporation, for Sunbeam Corporation, both of Chicago, Illinois, also permitted the over-all design of the sweeper unit with a low profile for maximum furniture clearance.

On the following page, you will find some additional examples of the basic design improvements made possible by the use of ZYTEL nylon resins.

DU PONT
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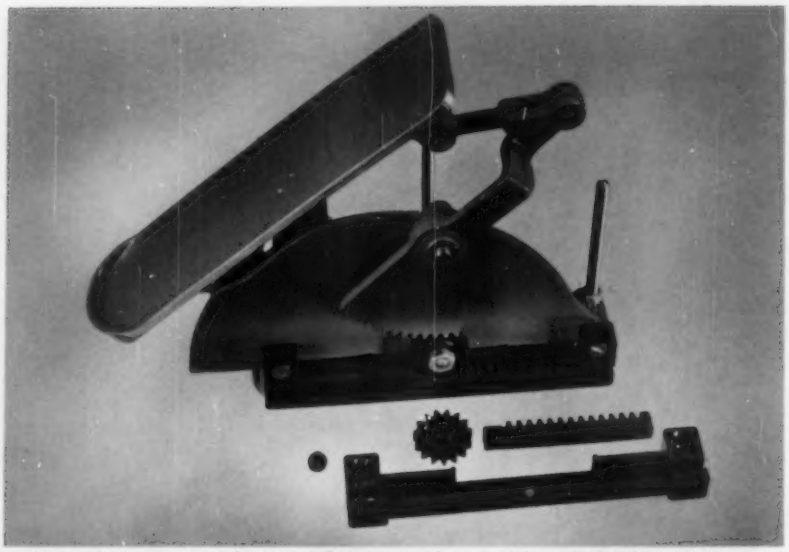
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

working with

Du Pont Zytel®

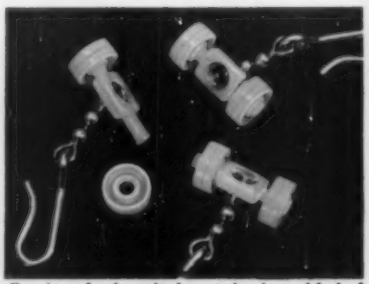
nylon resins

one of Du Pont's versatile engineering materials



Full-throttle foot control for motor boats is made with gear, rack, guide panel and anchor ball of ZYTEL nylon resins. The rack and anchor ball have threads molded in to accept the control cable and sheath respectively. The use of ZYTEL assures smooth, quiet operation of the foot control, and eliminates salt-water corrosion problems. In addition, the unit requires no lubrication. (Molded by Nylon Products Corporation, Clinton, Massachusetts, for Tempo Products Company, Cleveland 3, Ohio.)

Sleeve bearings for heavy machinery are made with sleeves of ZYTEL, reinforced with a steel backing that has indented perforations and press-fits into the bearing housing. The good flow characteristics of ZYTEL enable it to flow easily into place through and around the many perforations. ZYTEL provides the necessary abrasion resistance, impact strength and low noise factor. (Molded by Terhorst Manufacturing Company, Minot, N. D.)



Carriage for hospital curtains is molded of ZYTEL, which provides the smooth, silent operation required in hospitals. This long-wearing part is easily assembled by snap fitting, needs no lubrication. (By Capital Cubicle Company, Brooklyn, New York.)

Designed with ZYTEL® for smooth, quiet operation

The products on this page demand smooth, low-noise operation, as well as varying degrees of strength, abrasion resistance, corrosion resistance, and freedom from lubrication problems. In each case, the use of ZYTEL meets the combined design requirements and helps assure long, trouble-free operation.

Du Pont ZYTEL may help you, too, to save money by reducing production costs and giving improved performance under a variety of difficult conditions. Find out how by sending in the coupon. Also, ask for the new booklet on the properties and advantages of tubing of ZYTEL.

POLYCHEMICALS DEPARTMENT

DU PONT

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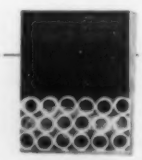

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☐ I am interested in evaluating ZYTEL for the following use:

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ZYTEL® *nylon resins*

Alathon® · Delrin® · Lucite®

Why it will pay you to

CONSIDER GLASS

before your products reach the blueprint stage

WHY GLASS?

It's versatile and basic.

And if it is a *Corning* glass, it offers your products these solid benefits:

Permanent finish. Corning glass compositions resist weather, chemical attack, abrasion and high temperatures. Their surfaces stay non-absorbent and non-porous — clean quickly.

Controlled transparency. Corning glasses are uniformly transparent—piece after piece, year after year. Colored or clear—they never lose their original clarity.

Hermetic enclosures can be made in rugged designs from special glasses developed for glass-to-metal fusion sealing.

Electrically conductive coatings. Fired on to glass, they are a very efficient source of radiant energy. They provide uniform heat distribution of a long wave length radiation readily absorbed by most materials.

Durability. Glasses with ingenious balances of mechanical, electrical and chemical properties plus correlation of form and shape insure a durable product.

Heat indifference. Corning glass keeps strength and finish at high temperatures—in some compositions from 900°F. to 1700°F. Heat indifference is furthered by designs that carefully distribute thermal stress.

Electrical stability. Corning glasses have high resistivity, low power losses, low and high dielectric constants, excellent non-tracking properties. They can also be furnished with special characteristics of high dielectric strength.

Chemical inertness. Corning glasses resist most atmospheres and chemicals even at relatively high temperatures—do not pit, scale or rust. They keep their chemical, mechanical and electrical properties indefinitely.

WHICH GLASS?

You can choose from five types of Corning glasses. These fill most needs. But, if you have an unusual application—one that cannot be met by any of the following types—special variations will be suggested.

Borosilicate glasses have high thermal endurance, softening points, chemical resistance, and excellent electrical stability.

High silica glasses have extreme thermal endurance, very high softening point, high chemical resistance, excellent electrical properties, and exceptional transmittance of the ultraviolet or the infrared.

Opal glasses have uniform and well-controlled translucence and good mechanical strength.

Lime glasses have controlled mechanical properties and excellent visual qualities.

Lead glasses have controlled mechanical and electrical properties and high visual quality.

WHERE GLASS?

Because you can get Corning glass in almost any shape or form you wish—because you can be sure of the definite and fine balance of properties required for your specific needs, you can use Corning glass in a wide range of applications. Some of these are:

Ovenware
Coffeemakers
Laboratory ware
Electrical insulation
Gauge glasses
Industrial piping
Range burner plates
Crucibles
Ultraviolet lamps
Thermocouple protecting tubes
Induction furnace linings
Electrical insulation
Lighting ware
Food service dishes
Refrigerator storage dishes
Incandescent lamps and stems
Tumblers
Vacuum bottles
Fluorescent lamps
Tableware
Refrigerator trays
Washer windows
Level vials
Fuses
Lampworked novelties
Bowls for food mixers

FREE BULLETIN

For more complete information on how you can advantageously use glass in your product design, send coupon for Bulletin IZ-1.

It lists specifications of the various types and forms of Corning glasses and tells how our design service can help you.

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Please send me a copy of Bulletin IZ-1, entitled "Designing with Glass for Industrial, Commercial and Consumer Applications."

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101 aluminum fabricators have ...Amchem's newest

ALODINE 1200S protects aluminum best ...at less cost, in less time!

To the hundreds of long-time users of Amchem Alodine—the first, low cost effective surface conversion treatment for aluminum—add a new host of fabricators who are employing the newest Alodine development—ALODINE 1200S!

If you are producing aluminum—any type of aluminum—you'll want to investigate the production advantages and profit potentialities of this new Alodine pre-paint process that provides constant, uniform quality as well as big savings in time, equipment and processing costs!

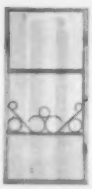
Through increased chemical activity ALODINE 1200S slashes processing time *up to 50 percent!* A 1200S system can be installed on your production line quickly and conveniently . . . and bath is maintained chemically . . . no special equipment required to control contamination! In an ALODINE 1200S system, products can be processed through continuous dip in the same time cycle other conversion coatings require for continuous spray lines! That means lower initial equipment and maintenance costs, wider range of product applications regardless of the application method—brush, dip, continuous strip or spray. ALODINE 1200S is qualified under Government Specification MIL-C-5541.

ALODINE 1200S is Amchem's positive answer to constant uniform quality in aluminum processing. Put its assured protection and production flexibility to work for your aluminum products and market them with greater confidence!

switched to Alodine 1200S conversion coating!

FASTER, LOW COST, EFFECTIVE AND FLEXIBLE, ALODINE 1200S IS PROVIDING NEW HIGHS

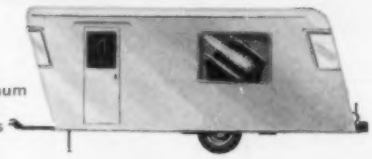
aluminum stop signs

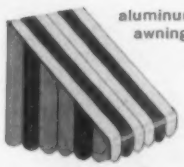

aluminum doors

aluminum venetian blinds

IN CORROSION RESISTANCE AND PAINT BONDING QUALITIES TO THESE AND

aluminum cameras


aluminum house trailers


aluminum awnings

MANY MORE FINE PRODUCTS IN THE ALUMINUM INDUSTRY. YOU, TOO, CAN

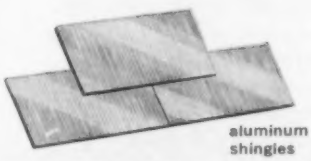
aluminum boats

aluminum license plates

aluminum missile parts

UPGRADE YOUR PRODUCTS' CONSUMER APPEAL WITH ALODINE PROTECTION.

aluminum siding


aluminum shingies

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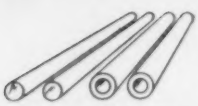
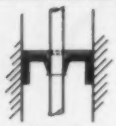
C NONMETALLIC MATERIALS AND FINISHES

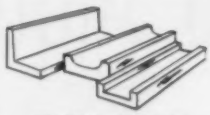

ROD AND TUBING

TORQUE CONTROL BUSHINGS

O-RINGS


SHAFT SEALS

BUSHINGS


BEARING SURFACES

VALVE SEALS

CUP PACKINGS

THRUST WASHERS

BASIC SHAPES AND FABRICATED PARTS IN

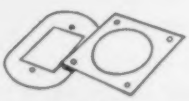
RULON®

REINFORCED TFE RESIN*

*Dupont Teflon

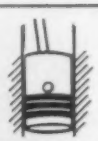
SHEETS

CUSTOM EXTRUSIONS


GASKETS

TAPE

BEARING RETAINERS


PISTON RINGS

Design engineers note! RULON adds extra values to your products . . . low friction performance even without lubrication . . . wide temperature adaptability (−350° to +500°F) . . . high resistance to wear and deformation . . . and practically universal chemical inertness. Unlike nylon and many other materials, RULON won't swell in presence of moisture.

See our Catalog in Sweet's Product Design File

RULON is the sure relief to many a design headache. For RULON engineering Brochure #9572, write

DIXON CORPORATION
BRISTOL, RHODE ISLAND

Dixon Suppliers of basic shapes and fabricated parts in Rulon and Teflon

128 CIRCLE 128 ON READER SERVICE CARD

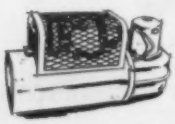
When you're choosing a protective coating...

HOW HOT IS YOUR HOT?

A Nose Cone Gets Hot

When conventional organic finishes were used in Chrysler Redstone Missile tests, they ignited and disintegrated under simulated re-entry conditions. Sicon survived because it possessed the inherent heat resistance to meet performance requirements. This has been confirmed in large scale tests and actual missile firings.

A Truck Heater Gets Hot



A porcelain type coating used on a truck heater failed because it could not stand the thermal shock of rapid heating and cooling. The same heating (550°-600°F.) and cooling left Sicon's film integrity unaffected.

A Tractor Engine Gets Hot

A farm equipment manufacturer used a bright organic red color on their standard equipment. The coating on the engine parts, which were subjected to high temperature, quickly decomposed. Midland engineers developed a matching bright Sicon Red which retained its color and gloss and protected the hot spots on the engine.

How HOT is your HOT?

Sicon possesses the flexibility of ordinary organic finishes and the heat resistance of ceramic coatings—up to 1000°F. in black or Aluminum; up to 550°-600°F. in decorative colors. Upon inquiry a sample Sicon formulation for testing your "hot" requirements will be prepared at no obligation. Send details of your "hot spot" problem today to Dept. I-31.

Sicon®

HEAT RESISTANT FINISH

A Silicone Product of

MIDLAND
INDUSTRIAL FINISHES COMPANY
WAUKEGAN · ILLINOIS
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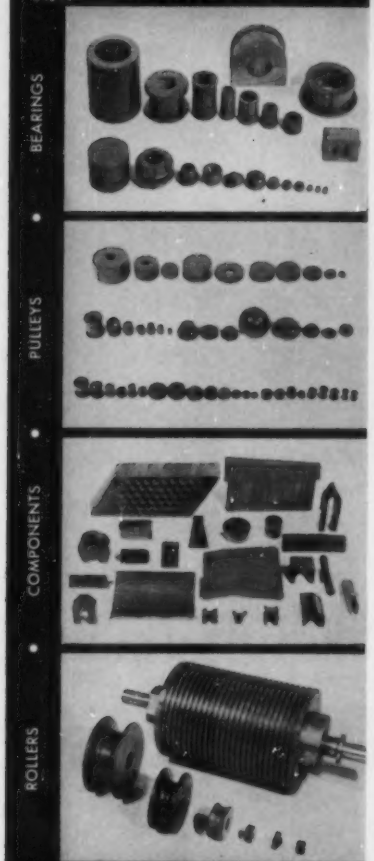
self-lubricating
BEARINGS—BUSHINGS and COMPONENTS



Solve your problems with . . .
SELF-LUBRICATING — CHEMICAL RESISTING —
NON-CONTAMINATING — FLUID RESISTING —
NOISELESS — LIGNUM-VITAE

LIGNUM-VITAE

Where Lignum-Vitae is adaptable, there is seldom any other superior material. Runs efficiently dry and wet . . . in fresh or salt water, in contact with many acids, chemicals and other materials. Being non-contaminating, it may be used in contact with edible foods and liquids.
The natural encapsulated lubrication never drips or leaks under proper application.
Lignum-Vitae is ideal for tough "trouble spots"; has unusual homogeneity, great compressive strength (up to 14850 psi). There have been applications where Lignum-Vitae Bearing, water lubricated, lasted ten to thirty times as long as Bronze or Babbitt. Also reduced power consumption 20%.

WE CAN SERVE YOU. UPON REQUEST. AS FOLLOWS:

- ☐ Technical Brochure; Summary of Lignum-Vitae Properties.
- ☐ Quote on Lignum-Vitae Bearings, Bushings and Components to specifications. (Send blueprint and application data)
- ☐ Price List: Lignum-Vitae Material, all forms.
- ☐ Price List: Most standard types of Lignum-Vitae Bearings and Bushings.
- ☐ Bulletin "How to use Lignum-Vitae (Material), Bearings, Bushings and Components."
- ☐ Send us the name and address of your favorite Bearing Distributor.

LIGNUM-VITAE PRODUCTS CORPORATION
111 Boyd Avenue, Jersey City (4), N. J.
Henderson 3-3027 (New York): Digby 9-0866

Catalogs and Bulletins.....continued

(C-66) **Thermoplastic Extrusions** — Brochure, 4 pp. Lists shapes, materials and services available. The Conneaut Rubber & Plastics Co, Box 621, Conneaut, Ohio.

(C-67) **Felt**—Catalog, 4 pp. Supplies twelve samples and a table of specifications, suggested uses. Continental Felt Co, 22 W 15 St, NYC.

(C-68) **Ceramics**—Brochures, 10 pp. Describes properties and uses of alumina and beryllia ceramics and oxide coatings. Coors Porcelain Co, 600 Ninth St, Golden, Col.

(C-69) **Plastic Parts**—Catalog, 8 pp. Contains dimensions, illustrations of phenolic knobs, handles, feet and meter cases. Harry Davies Molding Co, 1428 N Wells St, Chicago 10.

(C-70) **High Alumina Ceramics**—Brochure, 6 pp. Lists comparative properties of materials for electronics applications. Gives tables of standard rods, tubes and cylinders. Illustrates sample electronic components. Diamonite Products Mfg Co, Div of US Ceramic Tile Co, Shreve, Ohio.

(C-71) **Teflon Tape and Film**—Catalog, 19 pp. Describes some properties of the material. Gives price and size information on metallized films, pressure sensitive tape and other forms. Dilectrix Corp, Allen Blvd & Grand Ave, Farmingdale, NY.

(C-72) **Teflon Products**—Bulletin, 8 pp. Contains table of teflon properties. Shows molded teflon products such as bellows, packing, lined fittings and others. John L. Doré Co, Box 7772, Houston 7.

(C-73) **Silicones**—Brochure, 16 pp. Furnishes briefs on properties and uses of 250 silicone fluids, resins, rubbers, lubricants and other forms. Dow Corning Corp, Midland, Mich.

(C-74) **Silicone Rubber**—Brochure, 6 pp. Relates resistance to heat, cold, severe weather, ozone, atmosphere and compression set. Dow Corning Corp, Midland, Mich.

(C-75) **Silicone Electrical Insulation**—Brochure, 6 pp. Guides selection of silicone products for different insulating jobs. Dow Corning Corp, Midland, Mich.

(C-76) **Acetate and Butyrate Plastics**—Brochure, 20 pp. Discusses properties and typical uses of cellulosic plastics. Includes table of properties and illustrations. Eastman Chemical Products, Inc, Kingsport, Tenn.

(C-77) **Coatings and Cleaners** — Data folder, 34 pp. Describes chemicals and equipment for preparing metal surfaces for painting and welding. Neilson Chemical Co, 2300 Gainsboro, Detroit 20.

continued

MOLDED FIBER GLASS, of course!

MOLDED FIBER GLASS is fiber glass reinforced plastic, custom molded in matched metal dies by the Molded Fiber Glass Company.

MOLDED FIBER GLASS makes products better, at less cost, because:

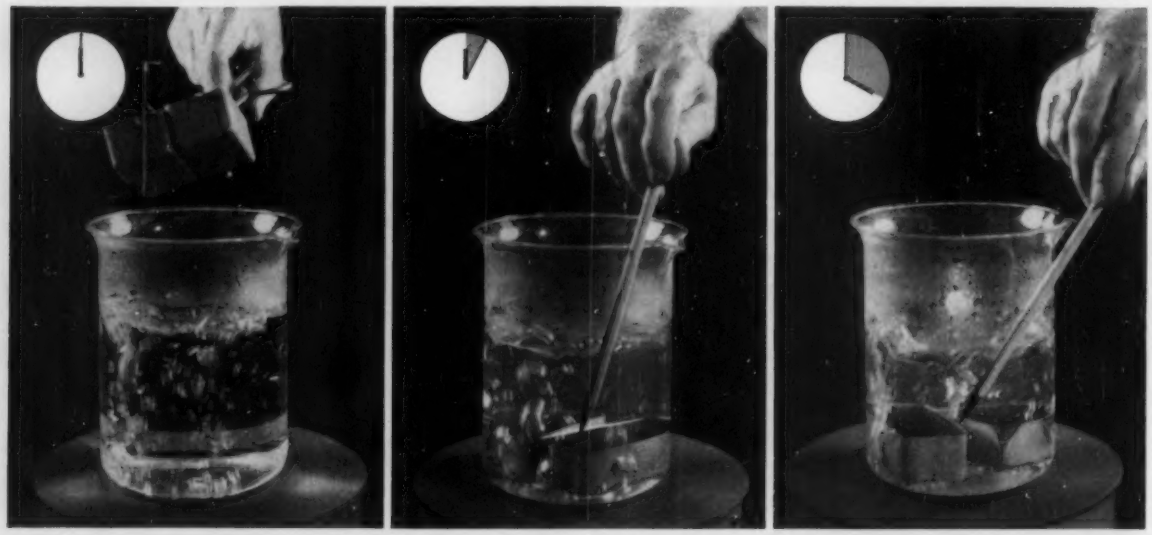
1. It can be molded into complex, deep-draw shapes which you can't make with metal;
2. It requires just half as much tooling time as metal;
3. It cuts tooling costs 80%;
4. It's beautiful, strong, lightweight, rust-proof and colors can be molded in.

Write today for descriptive brochure, and information on how you can make **your** products better at less cost with MOLDED FIBER GLASS.

Molded Fiber Glass Company

4423 Benefit Avenue
Ashtabula, Ohio

A DRAMATIC DEMONSTRATION OF THE NEW CLAD-REX 102 LAMINATE



Boiling water provides a positive test for two deep drawn* vinyl-clad parts. Neither special care in forming, nor post curing has been used to prepare either part.

Almost within a matter of seconds, the part formed of conventional vinyl-clad metal (at right) begins delaminating at the corners.

Even after as long as four hours of boiling, the part formed of new Clad-Rex 102 laminate (at left) still shows no delamination whatsoever.

New Clad-Rex vinyl-clad metal sharply reduces limitations in deep drawing and heat exposure

Has your interest in vinyl-clad metals been cooled because your product is deep drawn? . . . or because your product is exposed to elevated temperatures? . . .

Now, you can solve the problem with new Clad-Rex 102. It's a new vinyl-metal laminate that is, in effect, a single element of material. Clad-Rex 102 combines *for the first time* the ultimate properties of sheet metal with the optimum characteristics of vinyl.

Call or write for facts of this major technological breakthrough by the extensive research laboratories of Simoniz Company.

*Depth of draw equal to six times radius of corner

VINYL-METAL LAMINATES BY **CLAD-REX**® DIVISION OF SIMONIZ COMPANY

11516 W. King Street • Franklin Park, Illinois

Telephone: GLadstone 1-2323

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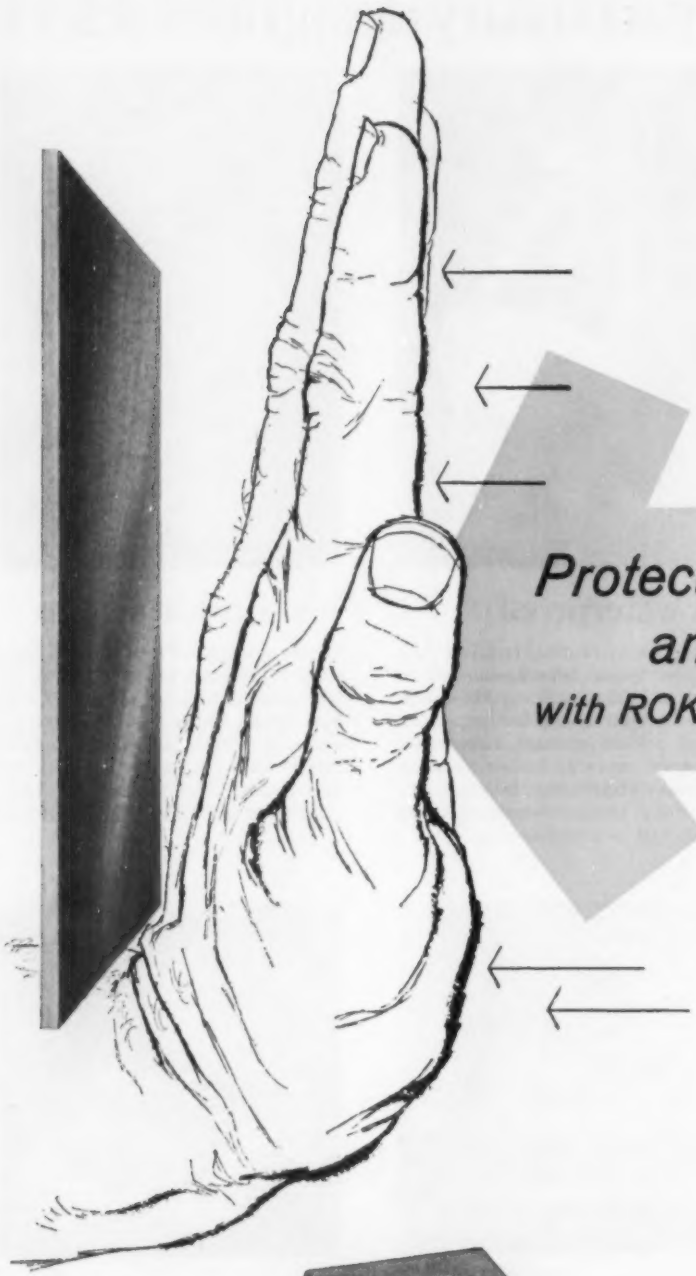


Here's the fast, economical way to protect vital parts and equipment against temperatures up to 4600°F . . . extreme abrasion . . . electrical energy . . . erosion and corrosion. Simply apply ROKIDE Ceramic Coatings — hard, crystalline refractory materials — which provide *positive* protection.

ROKIDE Coatings are supplied in rod form as "Z" Zirconium Oxide, "A" Aluminum Oxide, "C" Chrome Oxide, "ZS" Zirconium Silicate, and "MA" Magnesium Aluminate. To apply, rod is heated and the molten particles projected at high velocity against the prepared surface, where they adhere and solidify.

ROKIDE Coatings are extensively used for both military and industrial applications such as: missile components, bearing surfaces, extrusion dies, furnace and feed rolls, induction coils, igniter tips, strain gages, buffing fixtures, mechanical seal rings, pump shafts, capstan wheels, impellers, crucibles, etc.

Protect modern metals and materials

with ROKIDE Ceramic Coatings*

ROKIDE Coatings are available from a number of strategically located job shop applicators or direct from Norton Company, Worcester, Mass., and Santa Clara, California. Find out how they can cut *your* maintenance and production costs. NORTON COMPANY, 228 New Bond Street, Worcester 6, Massachusetts.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

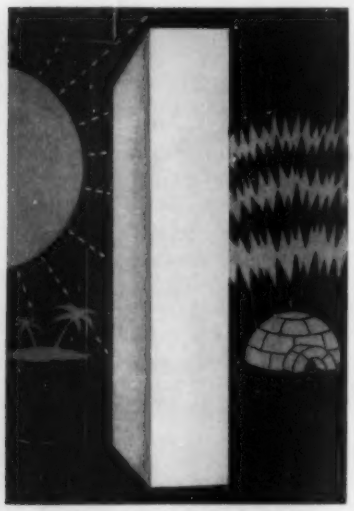
Write for full details on the ROKIDE Coating Process.

NORTON
REFRACTORIES
Engineered . . . Rx . . . Prescribed

75 years of . . . Making better products . . . to make your products better

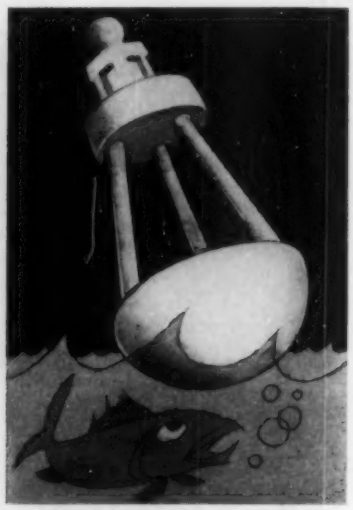
NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — BEHR-MANNING DIVISION: Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

Five reasons why so many designers select



It's an insulator

The Thermal Conductivity (K Factor) of DYLITE is 0.242 at a 75°F. mean temperature at 2 lb./cu.ft. density. DYLITE resists heat, is unaffected by moisture condensate. Cooler chests molded of DYLITE keep food and beverages cold for days without ice refill. DYLITE is easily molded to fit contours of component parts of refrigerators, air conditioners and freezer cabinets.



It's waterproof

At 2 lb./cu.ft. density, DYLITE's rate of Water Vapor Transmission is 1.18 perms., and its rate of Water Absorption is 0.54 lbs./cu.ft. after 48 hrs. immersion. DYLITE is ideal for boats, rafts, buoys and other types of buoyant marine equipment. DYLITE remains in the water indefinitely without becoming water logged, and it is mildew-proof.

It's shock-resistant

DYLITE possesses an Energy Absorption ratio (Maximum Load) of 56.74 in. lbs./cu.in. at a density of 2 lb./cu.ft. For example, Royal electric typewriters are now shipped in shock-absorbent DYLITE packages—a result of performance tests in which DYLITE was proved superior to other materials for this job.

TYPICAL PROPERTIES OF DYLITE EXPANDABLE POLYSTYRENE—DENSITY 2 LB./CU.FT.
- Compressive Strength—30 Psi • Tensile Strength—55 Psi • Water Vapor Transmission—1.18 Perms.
- Water Absorption—0.54 Lbs./Cu.Ft. • Thermal Conductivity (K Factor)—0.242 at a 75°F. Mean Temperature
- Energy Absorption (Maximum Load)—56.74 In. Lbs./Cu. In.

DYLITE is a registered trademark of Koppers Company, Inc.

DYLENE® polystyrene, SUPER DYLAN® polyethylene and DYLAN® polyethylene are other fine plastics produced by Koppers Company, Inc.

Offices in Principal Cities • In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

DYLITE® expandable polystyrene

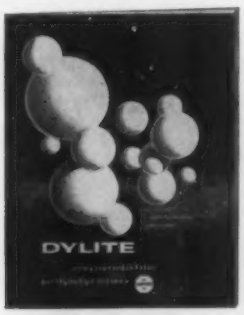
It's lightweight

DYLITE is lighter than cork—it can be molded in densities of 1 to 10 lb./cu.ft. The advantages of light weight are obvious. In packaging, DYLITE helps reduce shipping costs and makes handling easier. In the construction field, where DYLITE is used as an insulator, its light weight means fast and easy installation.

It's strong

DYLITE has a Compressive Strength of 30 psi and a Tensile Strength of 55 psi at a 2 lb./cu.ft. density. DYLITE can be used to great advantage in a wide variety of industrial design problems. For instance, sandwich structures that employ DYLITE as the core material offer high strength without sacrificing light weight.

... if you would like more information about versatile DYLITE expandable polystyrene, write for this free booklet.



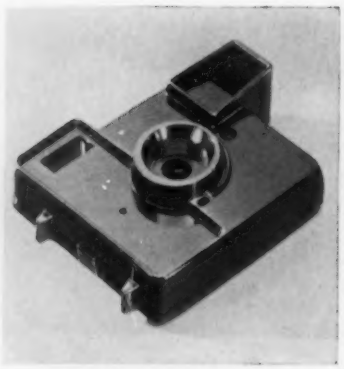
Koppers Company, Inc.
Plastics Division
Dept. PE 90,
Pittsburgh 19, Pa.

KOPPERS

DUREZ

PHENOLIC RESINS AND MOLDING COMPOUNDS
DIALLYL PHTHALATE COMPOUNDS
FIRE-RETARDANT POLYESTER RESINS

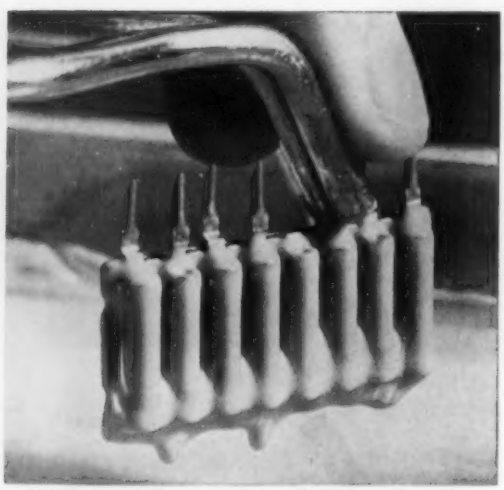
For the designer who spells



LOWER-COST general-purpose phenolics, proved in all manner of applications for forty years. These workhorses of industry account for thousands of applications—not only because they cost less but because nothing has come along that does things better: housings, cases, large and small parts requiring a balance of such properties as strength, non-conductivity, smooth surface, resistance to heat, cold, chemicals.

NON-BLEEDING PHENOLICS that are resistant to alcohol, essential oils, and other solvents and impart no color or flavor to foods, perfumes, cosmetics and other bottled products. For baby-bottle nursing top and caps we offer molding compounds which will stand repeated autoclave sterilization at 275°F, with many combinations of torque strength, surface finish, moisture resistance and other properties. They are formulated for high-speed molding on automatic presses.

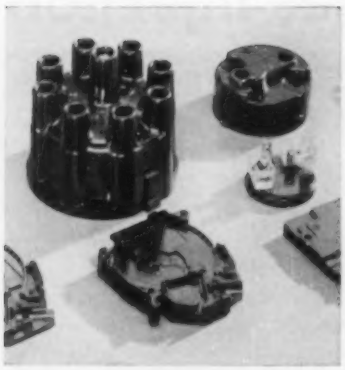
GREATER IMPACT RESISTANCE for products subject to rough handling. For these Durez can help you choose from a broad range of shock-resistant phenolic compounds for telephone parts, gears, bushings, pulleys and structural components. These range from 0.3 to 17.0 ft.-lb./in. impact. With strength like this, there's no need to run up costs by overengineering or by staying with unsatisfactory materials.



BONDING, IMPREGNATING, laminating and coating resins are also available from Durez in hundreds of formulations for use in abrasives, reconstructed wood, friction materials, rubber compounds, and corrosion-resistant mortars. Other types include shell-mold resins that are helping foundries produce better castings. Coating resins contribute important properties to printing inks, and to brushing or spraying finishes.

LARGE STRUCTURAL SHAPES such as this outboard motor shroud are stronger and safer when molded with Hetron® polyester resin and fibrous glass. Hetron laminates and molded parts do not support combustion. Fire resistance is inherent—chemically locked in without the use of weakening additives. Corrosion resistance, and the ability to take a baked-on finish without crazing, are other key qualities.

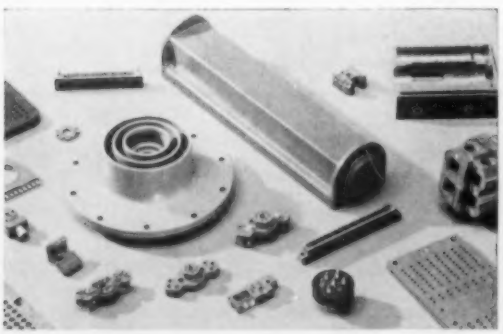
out tougher specifications...



DESIRABLE ELECTRICAL PROPERTIES, combined with light weight and dimensional stability, can be obtained in Durez electrical grade phenolic molding compounds. They find wide use in automotive ignition parts, resistor casings, coil forms, tube bases, and electronic components of many types. Some of these compounds are formulated especially for molding around large inserts. Several are designed to meet military specifications.

HEAT RESISTANCE combined with high non-conductivity and other desirable electrical properties is also available in Durez molding compounds. Most compounds in this class are designed to take 72-hour heat-treatment at 392°F. Some will survive 450°F for relatively long periods, and higher temperatures for shorter periods, without serious impairment of physical properties or molded appearance. They find wide use in electrical appliances.

SPECIAL PROPERTIES in unusual combinations are available in Durez phenolics. Examples: low modulus of elasticity combined with other wanted properties. Or outstanding chemical and moisture resistance combined with high mechanical strength, as in this sump-pump impeller. By formula variations and the skills of compounding learned over a forty-year period, Durez can give you resins and molding compounds that fit any job.



SPACE-AGE PERFORMANCE often requires super-plastics such as Durez diallyl phthalate molding compounds. Reinforced with orlon or glass fiber, these materials are virtually free from cold flow and creep. They retain high electrical insulation values at relative humidities above 90% and over a wide temperature range. Their reliability has led to their wide use in rocket and missile components and in many other electrical and electronic systems.

FACTS, IDEAS for your files are available in illustrated bulletins and data sheets. These contain full descriptions of Durez materials, including properties, uses, design suggestions, facts on molding and finishing. For latest application information, ask us to send you **Durez Plastics News,** mailed periodically, and packed with information on new products and uses.

DUREZ PLASTICS DIVISION

HOOKER CHEMICAL CORPORATION, 1514 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICALS PLASTICS

HERCULES Plastics Hi-Lites

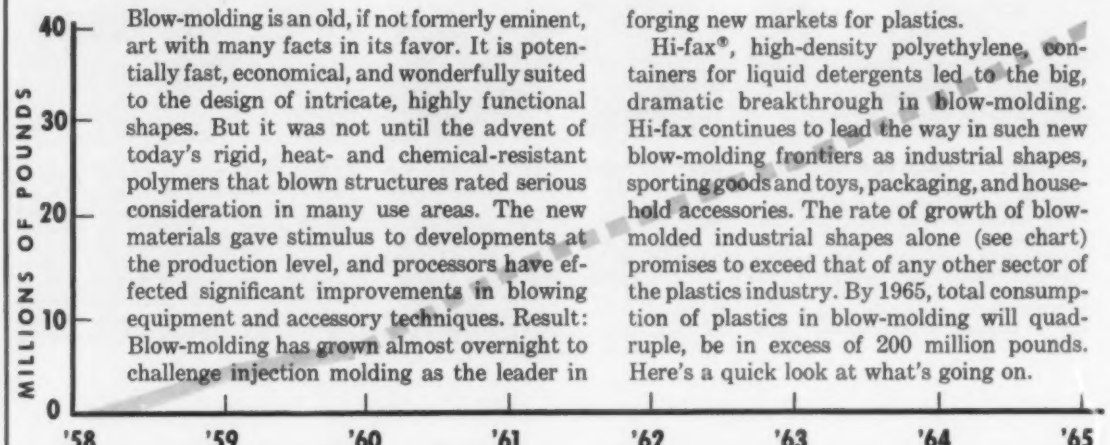
Vol. II, No. 2

Blow-Molding challenges injection

As blown containers move full steam ahead, engineers see sizeable new markets for many types of blown structures.

Blow-molding is an old, if not formerly eminent, art with many facts in its favor. It is potentially fast, economical, and wonderfully suited to the design of intricate, highly functional shapes. But it was not until the advent of today's rigid, heat- and chemical-resistant polymers that blown structures rated serious consideration in many use areas. The new materials gave stimulus to developments at the production level, and processors have effected significant improvements in blowing equipment and accessory techniques. Result: Blow-molding has grown almost overnight to challenge injection molding as the leader in forging new markets for plastics.

Hi-fax®, high-density polyethylene, containers for liquid detergents led to the big, dramatic breakthrough in blow-molding. Hi-fax continues to lead the way in such new blow-molding frontiers as industrial shapes, sporting goods and toys, packaging, and household accessories. The rate of growth of blow-molded industrial shapes alone (see chart) promises to exceed that of any other sector of the plastics industry. By 1965, total consumption of plastics in blow-molding will quadruple, be in excess of 200 million pounds. Here's a quick look at what's going on.



PROJECTED GROWTH OF BLOW-MOLDED INDUSTRIAL SHAPES

(1965 consumption of all forms of blow-molding will be in excess of 200 million pounds)

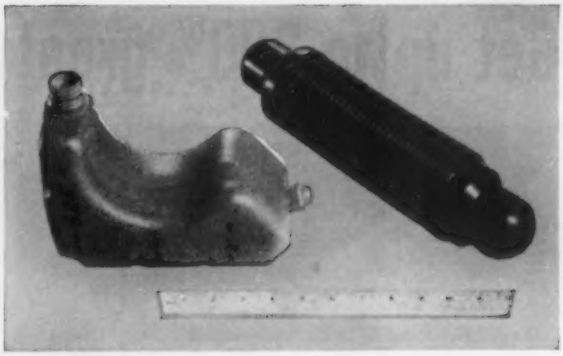
HOLD EVERYTHING?

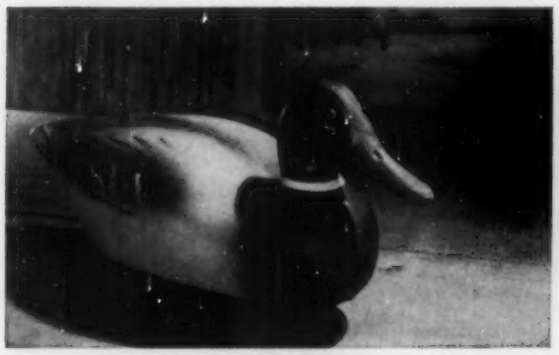
WELL, NOT QUITE

The leading and pioneer material among the new polymers used in blow-molding is Hi-fax, high-density polyethylene. Hi-fax bottles are continually undergoing torture testing at the Hercules Plastics Applications Laboratory, where hundreds of candidates for plastics packaging have been checked out (see cut). Hi-fax won't package everything, and such testing has pointed up the few instances where the product was not compatible with plastic containers. No other high-density material has such an extensive exposure history either in the laboratory or in actual commercial use.

INDUSTRIAL SHAPES

Advanced automotive engineering concepts such as these point the way to tremendous growth in the use of Hi-fax for blown industrial shapes. The complex shape of windshield solution container (left) makes it possible to utilize former under-the-hood waste space in a compact car. Built-in bellows feature of high-density heater duct (right) provides a flexible, low-cost part adaptable to rapid, economical assembly. Both parts exemplify the fine combination of properties and processability offered by Hi-fax blown structures.





SPORTING GOODS AND TOYS

Blow-molded Hi-fax shapes offer the short, fast, low-cost route to the production of readily merchandised sporting goods and toys. Lifelike realism achieved in the duck decoy shown at left is typical of the effects possible with Hi-fax. Exciting new surface textures, excellent mold detail reproduction, and a broad color spectrum, combined with lightweight toughness, in a pleasant-to-handle, nontoxic material, make blown Hi-fax shapes a natural for these fast-moving, highly competitive markets.

DRUGS AND COSMETICS

Hi-fax has greatly broadened the horizons of designers of blown containers. Its combination of rigidity and chemical resistance now permits the use of plastic packages for a wide variety of drug and cosmetic products in exciting new shapes. Unique "Whitey the Whale" container in background holds bubble bath solution; later will serve as an appealing toy. Hi-fax blown shapes are ideal for secondary use and premium packages, at down-to-earth prices competitive with metal and glass.

HOME AND OFFICE

This handsome group of lampshades is a good example of the interesting and pleasing blown shapes which can be achieved in home and office accessories. Hardware, housewares, machine housings and decorative fittings are all fields where the esthetics and economy offered by Hi-fax blow-moldings must prompt their immediate consideration by all forward thinking producers.

Want more information about blow-molding? Look to the leader and pioneer in this field. Call or write:

CP60-5

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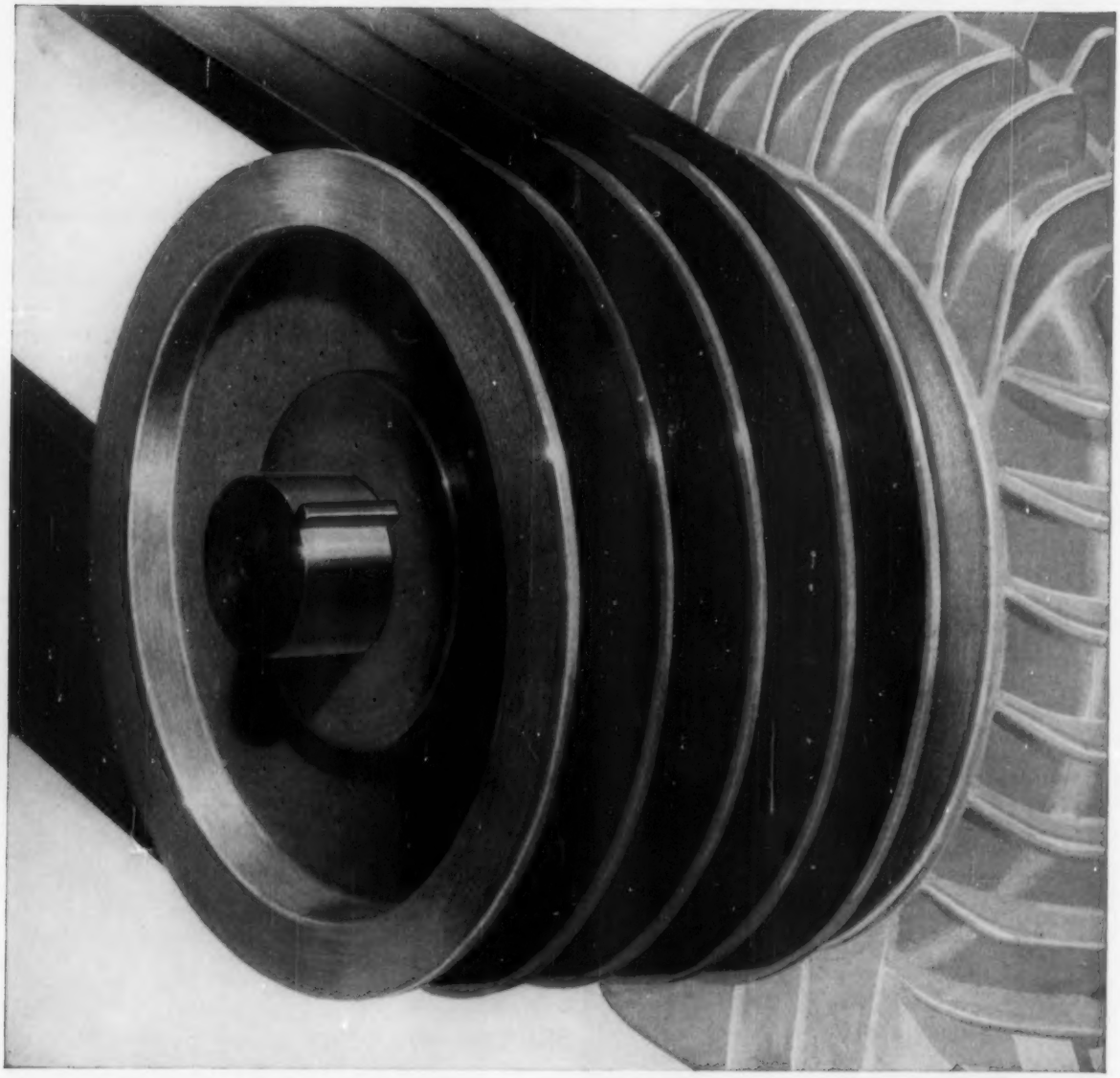
Get up to 300% greater horsepower per belt!



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You'll get up to three times the horsepower of ordinary belts when you specify super-rated V-belts reinforced with Du Pont "Dacron"* polyester fiber. Super-rated belts reinforced with "Dacron" give you greater horsepower without an increase in drive size. Or they give you more compact drives without a sacrifice in power . . . plus amazing resistance to shock loads and flexing.

For the next drive you install, be sure you specify super-rated V-belts reinforced with tough, long-wearing Du Pont "Dacron". Du Pont makes the "Dacron" fiber used by belt manufacturers in producing their finest-quality V-belts.

FREE BOOKLET: "Du Pont 'Dacron' Sets New Standards for V-Belt Performance". Write: E. I. du Pont de Nemours & Co. (Inc.), 31E Centre Road Bldg., Textile Fibers Department, Wilmington 98, Delaware.

*"Dacron" is Du Pont's registered trademark for its polyester fiber.

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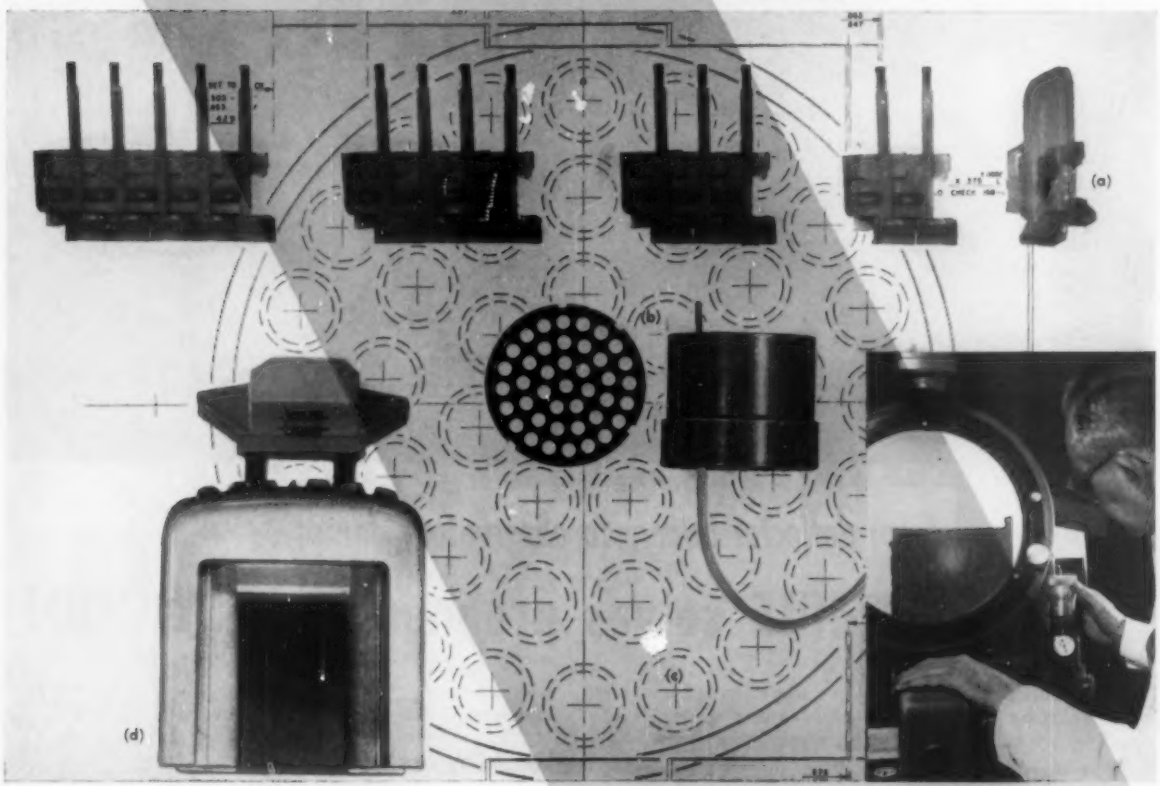
KEEP AHEAD WITH HAVEG

PRECISION PLASTIC MOLDINGS

"Haveg offers the most complete precision plastic molding facilities, experience and 'know-how' available anywhere."



(a) A series of crab locks molded from Nylon.
(b) Electrical connectors for making and breaking as many as 41 electrical circuits at one time are used in missile tracking equipment.
(c) Comparator chart in background enlarges connectors 10 times and checks the accuracy of all holes and insets.
(d) Pick-up head for stereophonic record player. This is a complicated but very small part (one third the width shown) in which three insets are molded into the head.

That's a strong statement but a very important one to remember in planning any type precision molding project. Haveg works with every known material to provide the most economical moldings . . . with properties necessary to meet the most rigid specifications.

Today Haveg is literally making design dreams come true . . . through its extensive research and development laboratory facilities as well as the best quality control laboratory within the industry.

Quality claims are made by many BUT Haveg and only Haveg provides the expert tool design and construction, equipment instrumentation, careful testing of incoming materials as well as many other specialized operations so necessary to assure highest quality precision moldings.

Haveg is justifiably proud of its unsurpassed versatility in facilities and engineering experience . . . we will be happy to put them at your disposal. Why not consult us on your next project . . . you'll find it pays to . . . keep ahead with Haveg.

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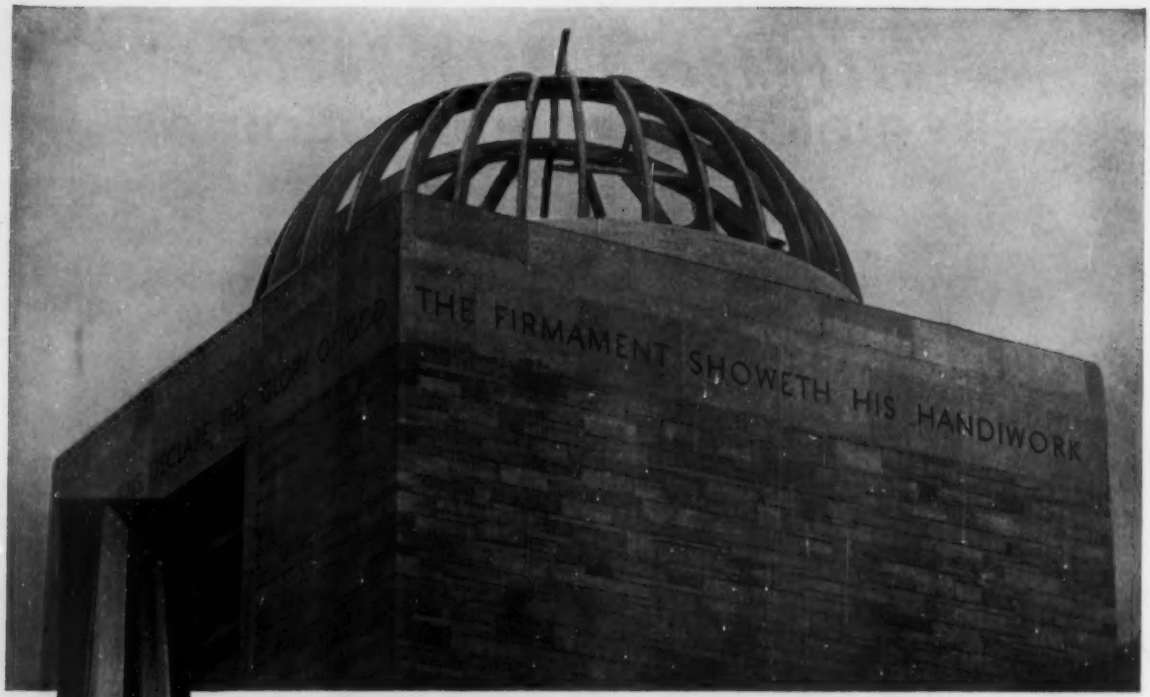
CIRCLE 139 ON READER SERVICE CARD 139



from deflector bars...to observatory domes...

GAMBLE solves problems with WOOD!

PROBLEM: Solid wood conveyor deflector bars were splitting and breaking from repeated impact of conveyed objects, causing downtime expense.

SOLUTION: Gamble wood engineers developed a *laminated hickory* deflector bar—thinner and more resilient, yet with greater and more uniform strength (due to lamination and the characteristics of hickory).

PROBLEM: Butler University, Indianapolis, needed a hemispherical dome for its J. I. Holcomb Observatory. The material for the 360-degree-rotating dome had to offer maximum dimensional stability *plus* beauty in keeping with the overall design.

SOLUTION: Gamble Brothers provided curved, laminated, wooden ribs for the 24-foot Observatory dome, and another giant "umbrella frame" for the Planetarium dome.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers —a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4617 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GB GUARANTEED BOND

GAMBLE BROTHERS, INC.

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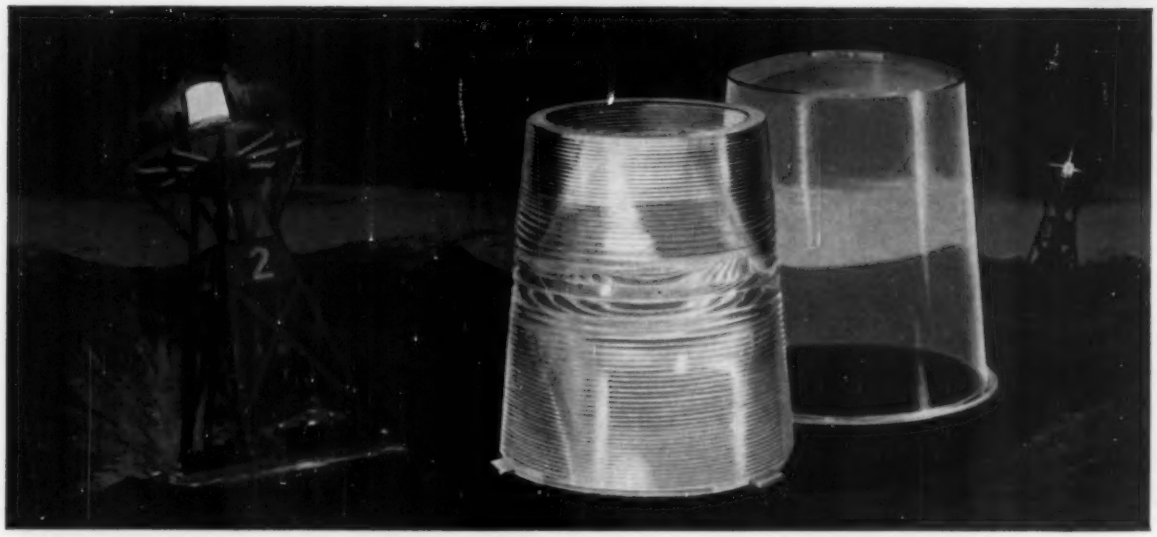
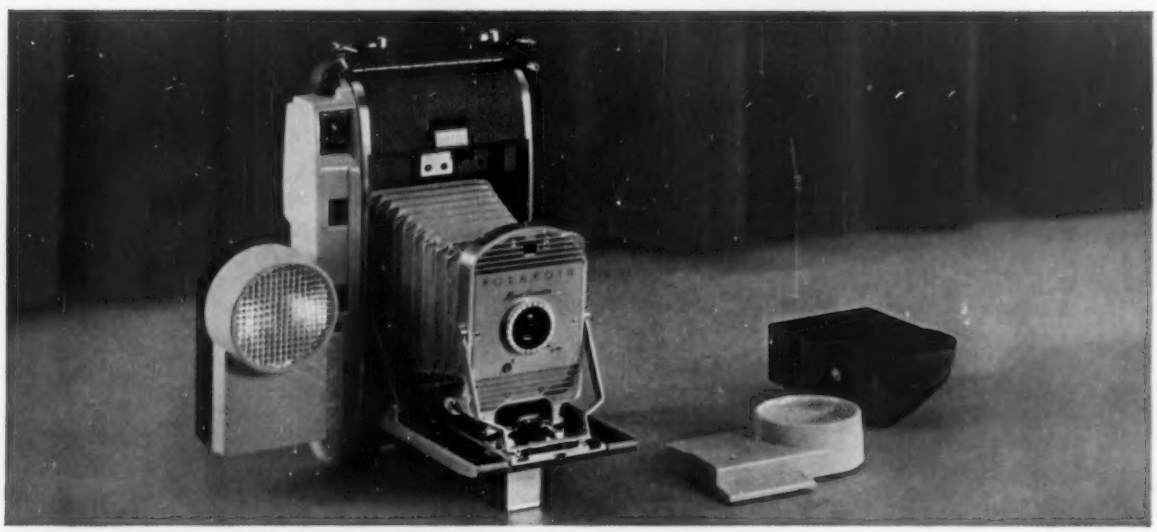


Handsome and Hardworking
Plexiglas ... Implex



Flashing lights at sea shine brightly through large lenses and covers molded of PLEXIGLAS® acrylic plastic. The PLEXIGLAS parts are used in navigation lights for the U. S. Coast Guard, at a fraction of the cost and weight of cut glass lenses. Precision molding of the lens pattern gives the PLEXIGLAS lens maximum efficiency in light control, and the material resists weather, breakage and salt water.

Winking lights at home are revolutionizing indoor photography by making indoor pictures without flashbulbs possible, with the new wink-light attachment shown above. Tough IMPLEX®, the high impact acrylic, gives handsome appearance and rugged durability to the housing. PLEXIGLAS is used for the lens.

We will be glad to help *you* use these Rohm & Haas acrylic molding materials—to your advantage.

Chemicals for Industry

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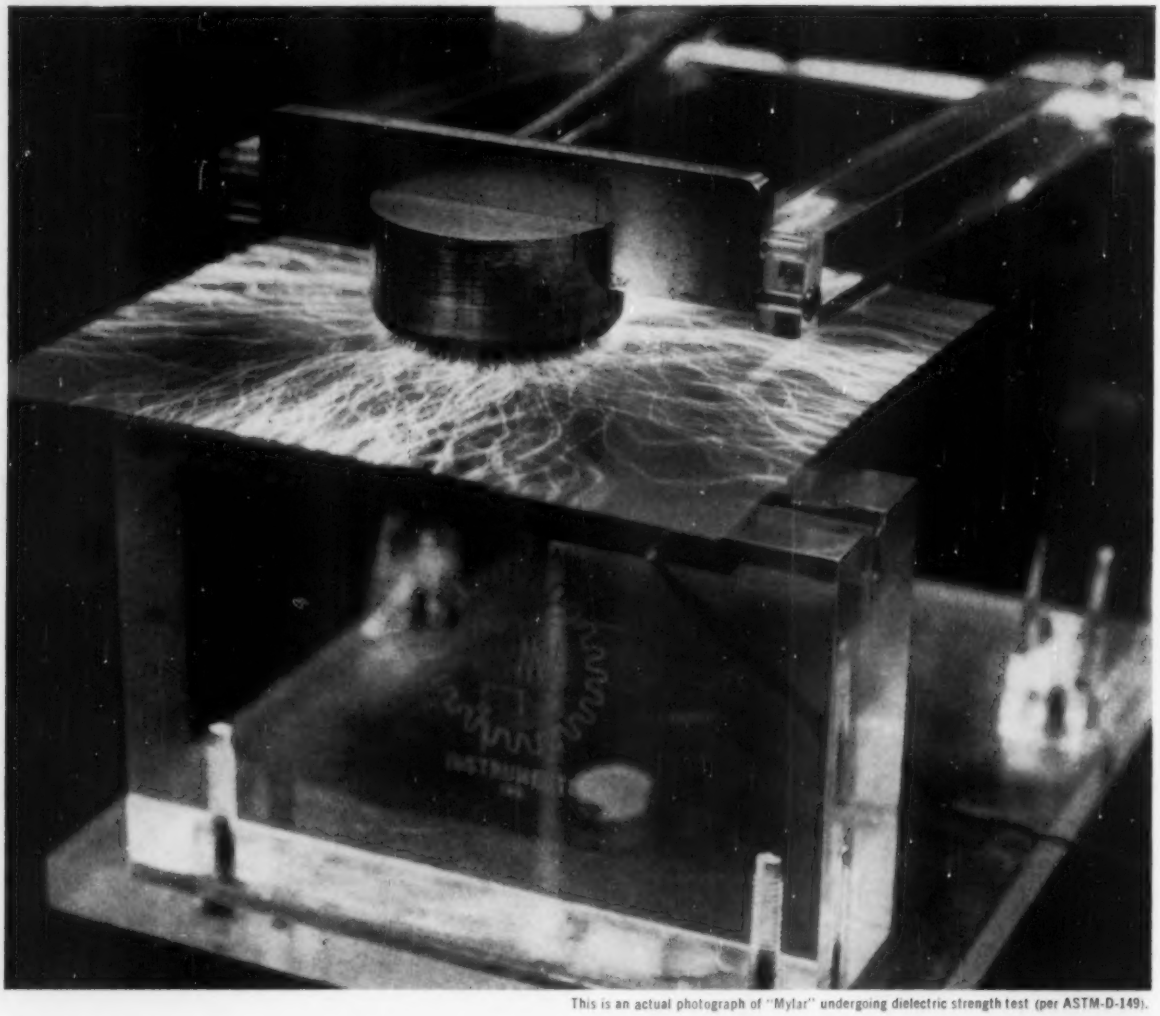
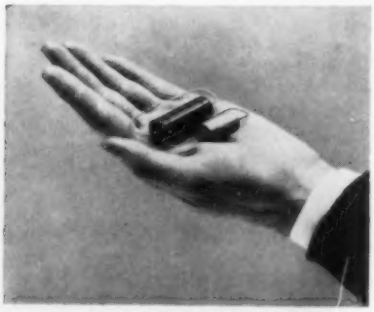


This is an actual photograph of "Mylar" undergoing dielectric strength test (per ASTM-D-149).

MYLAR® has a dielectric strength of 4,000 volts per mil

Can the unique combination of properties found in "Mylar" help you solve your design problems?



High dielectric strength helps cut capacitor size. Tough, thin "Mylar" with a dielectric strength of 4,000 volts per mil for 1 mil film (per ASTM-D-149) permits capacitor manufacturers to reduce size of finished unit . . . improve performance and reliability.

"Mylar"* polyester film is a tough, flexible engineering material. In addition to its outstanding dielectric strength, "Mylar" has an average tensile strength of 20,000 psi, withstands temperature extremes (-60° to 150° C.) . . . resists most chemicals and moisture.

On an area basis, tough, thin "Mylar" often *costs less* than heavier, conventional materials. "Mylar" can be laminated, embossed and metalized, punched or coated. The film won't embrittle with age. "Mylar" is available in roll or sheet form in a wide range of gauges.

Find out how the *combination of properties* in "Mylar" can help you solve knotty design problems, improve product performance or cut costs. Write for our booklet containing detailed information on properties and applications. E. I. du Pont de Nemours & Co. (Inc.), Film Dept., Room P-9, Wilmington 98, Del.

*"Mylar" is Du Pont's registered trademark for its brand of polyester film.

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. . . THROUGH CHEMISTRY

DU PONT MYLAR® POLYESTER FILM

do you know these facts about this fabulous plastic?

Do you know that:

- National Vulcanized Fibre is not a paper, or a fiber-board, but a tough cellulosic plastic . . . the oldest plastic of all!
- Despite a parade of new exciting plastics (and we make many of them), Vulcanized Fibre goes on sparking thousands and thousands of bright, new, cost-cutting ideas that other plastics aren't equal to!
- Vulcanized Fibre offers a most unusual combination of electrical and mechanical properties, giving your imagination more leeway, and *you* a greater chance of fingering the exact properties you want!
- National Vulcanized Fibre has outstanding arc resistance, low thermal conductivity, amazing resiliency and shock-absorbency, high abrasive resistance. It is fungus resistant. It soaks up noise!
- National Fibre can be formed or deep-drawn into intricate shapes; and machined, polished, painted, lacquered, embossed . . . even used in combination with other materials, such as aluminum, wood, rubber, copper.
- When used for railroad track insulations, Vulcanized Fibre can take the constant pounding of trains, yet can gently *cushion* fragile electronic parts, when used for containers. And it has stood up under 22,000° F for ten seconds without serious loss in weight!
- Vulcanized Fibre weighs half as much as aluminum, one-third as much as steel, is smooth as glass, and is one of the *strongest* materials known per unit of weight!
- There are sixteen standard grades, including a fire-resistant "Pyronil." And the cost of National Vulcanized Fibre is in the cents bracket, compared to dollars for many other types of plastics.
- *This* could be the plastic you are looking for now!

For help on a present problem, or for information on National Vulcanized Fibre and samples, just write Dept. R , or contact your nearby NVF Sales Office. You'll find the 'phone number in Sweet's Product Design File 2b/Na.

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TROYFELT *. . . by the pioneers in non-woven synthetic felts*

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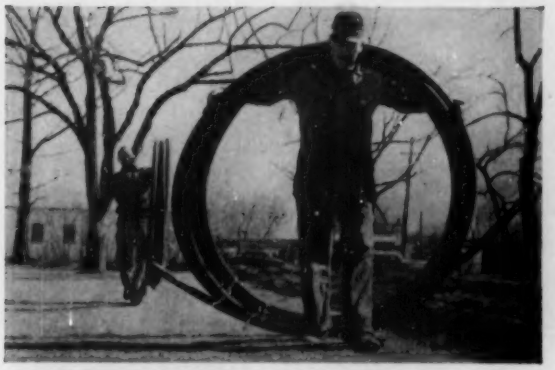
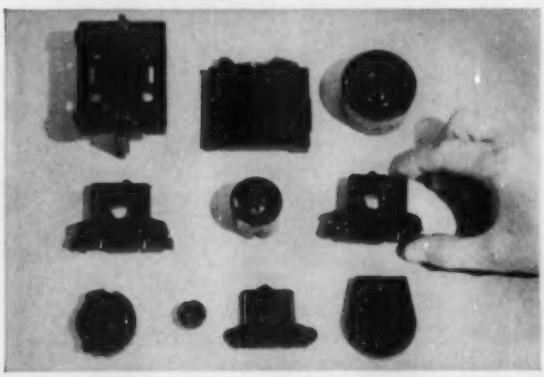
Know the Design Advantages of these Plastics

(You'll profit by keeping up to date)



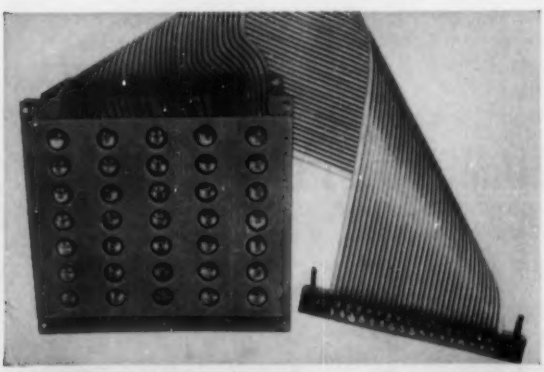
POLYETHYLENES: Light weight with strength. This 100 ft. coil of 2-in. polyethylene pipe is easily supported by one man. Flexible and rigid polyethylenes each have outstanding physical, chemical and electrical properties. Gas permeability and a broad range of colors make polyethylene film ideal for packaging.

EPOXIES: With its coils embedded in epoxy, this motor is running under water. The strongest and hardest of plastics, epoxies are ideal for industrial coatings and reinforced laminations, including medium-to-long-run tools and dies. They are extremely tenacious when used as adhesives.



PHENOLICS: These electrical parts illustrate one of the long-time uses for phenolic plastics. Strong and durable, phenolics are also molded into washing machine agitators, furniture drawers, bottle caps . . . They are also excellent for chemical-resistant coatings and industrial or decorative laminates.

STYRENES: Television masks like these exhibit the superior eye-appeal of styrenes. A range of impact strengths, brilliant colors, and gleaming finish broaden the design applications of these materials. Molded and extruded, styrenes find use as refrigerator door liners, toys, packages, and housewares.



VINYLS: This flexible printed circuit has copper conductors laminated between layers of vinyl sheeting. Vinyls combine electrical resistance, formability, color, and elastomeric qualities. Tough, handsome vinyls can be fabricated into flexible or rigid film and sheeting. Inflatables, swimming pool liners, packaging, and wire insulation are important uses.

Get more detailed information about these design materials now. Mail the coupon for your "1961 Materials and Data Guide" to BAKELITE Brand Plastics. For specific technical assistance just write or call any of our offices, outlining your problem.

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A 5000° flame takes ten minutes to penetrate a one-quarter inch piece of CDF's new Dilecto RD-105 laminate. The same thickness of cold-rolled steel is pierced in less than forty seconds.

Molded from graphite fabric impregnated with a heat (ablation)-resistant phenolic resin, new CDF grades RD-105 and RD-115 are being evaluated in solid propellant rocket motors.

Dilecto laminates are only one family of products from industry's largest selection of non-metallic structural materials and electrical insulations. Vulcanized fibre, silicone rubber and mica, and thermosetting moldings are also supplied by CDF.

CDF can provide both quality and true economy in selecting plastic materials best suited to your needs. Refer to SWEETS PD file or write to us for General Folder 60.

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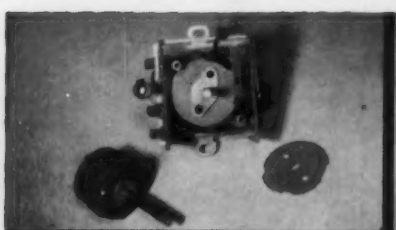
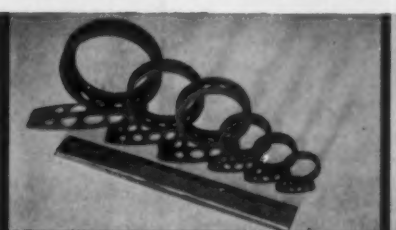


Moisture-resistant and low cost Dilecto cams for automatic washer and dryer controls.



Dimensionally stable, light weight, oil-resistant Dilecto ball bearing retainer rings.

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POLYPENCO® MC NYLON

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New processing techniques drop nylon tubular bar prices as much as 50%

ROD AND SLAB

Rod up to 17" in diameter, and slab from 1 to 5 inches thick in sections of 2 ft. x 3 ft. are available on special request. Other symmetrical shapes—produced with new economy—and in larger sizes than heretofore produced—are under development.

New design opportunities are open to manufacturers and users of large bronze and babbit bearings.

POLYPENCO MC Nylon 901, a specially formulated bearing compound, is available in tubular bars at prices below those of quality bronze bushings.

Polymer's new MC Nylon has improved wear characteristics and greater resistance to deformation under load . . . proven by field tests.

TUBULAR BAR STOCK SIZES

MC Nylon tubular bars, the first standard availability in MC Nylon, are made in outside diameters ranging from 2" to 15". Wall thicknesses of ⅛", ½", ¾" and 1" are standard with wall thicknesses up to 2" made to order. Standard lengths up to 13". Supplied in POLYPENCO blue.

Call or write today for full information.

The Polymer Corporation of Penna.
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Catalogs and Bulletins.....continued

(C-78) **Laminated Plastics**—Catalog, 4 pp. Provides engineering data, specifications and recommendations for applications of various grades. Plastics Div, Farley & Loetscher Mfg Co, 7th & White, Dubuque, Iowa.

(C-79) **Molding Compounds**—Catalog, 60 pp. Gives uses and properties of high impact phenolic, melamine and epoxy compounds. Also lists properties of molded products. Includes data on available preforms. The Fiberite Corp, 510-525 W Fourth St, Winona, Minn.

(C-80) **Diallyl Phthalate Resin**—Brochure, 12 pp. Presents data on properties, uses and advantages for molding, laminates and other applications. Chemicals & Plastics Div, Food Machinery & Chemical Corp, 161 E 42 St, NYC 17.

(C-81) **Mica**—Data sheets, 6 pp. Provides mica properties, specifications for sheets and stamped washers. Ford Radio & Mica Corp, 536-540 63 St, Brooklyn 20.

(C-82) **Epoxy**—Catalog, 38 pp. Explains characteristics, how to use epoxy adhesives, coating, sealants, plastic alloys. H B Fuller Co, 255 Eagle St, St Paul, Minn.

(C-83) **Laminated Plastic**—Catalog, 16 pp. Gives materials, characteristics of sheet, tubes, rods. Includes copper clad laminates. General Electric Co, Laminated Products Dept, Coshocton, Ohio.

(C-84) **Plastics, Chemical Materials**—Catalog, 12 pp. Presents tables and graphs of chemical, physical, thermal and electrical properties of polycarbonate resins, phenolic resins, varnishes, molding powders, fused magnesium oxide. Chemical Materials Dept, General Electric Co, 1 Plastics Ave, Pittsfield, Mass.

(C-85) **Silicones**—Brochure, 8 pp. Describes anti-foam agents through paint and rubber. General Electric Co, Silicone Products Dept, Waterford, N. Y.

(C-86) **Liquid Silicone Rubber**—Brochure, 11 pp. Gives properties and examples of some sealing, encapsulating and insulating uses. General Electric Co, Silicone Products Dept, Waterford, NY.

(C-87) **Thermoplastic Sheet**—Brochure, 10 pp. Furnishes samples, tables of properties, discussion of forming methods. Bolta Products Div, The General Tire & Rubber Co, 70 Garden St, Lawrence, Mass.

(C-88) **Rubber and Plastics**—Brochure, 16 pp. Provides specifications for over 50 rubber compounds. Outlines capabilities for makirg extruded plastics and molded or extruded rubber. The General Tire & Rubber Co, Industrial Products Div, 1218 Garfield St, Wabash, Ind.

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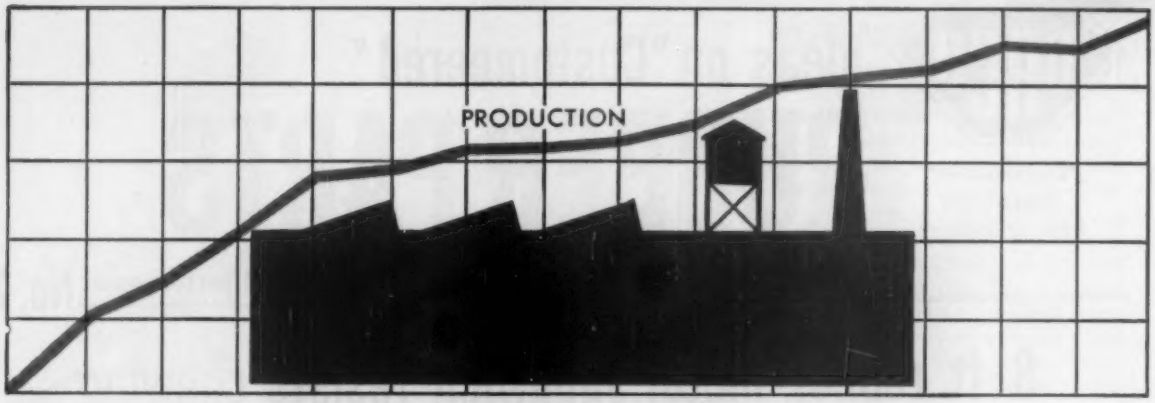

How to expand without added expenditure

Right away let's make this point clear: you won't find any magic formula here for expanding your plant physically at no cost. What you *will* find are facts about a material that can definitely help expand your plant's productivity . . . and your product's salability.

That material is Masland Duran Clad, the new semi-rigid vinyl for laminating to metal sheets or coils according to your specifications . . . the built-in finish that obsoletes dipping, spraying, brushing, coating and similar finishing methods . . . the vinyl-to-metal laminate that can even do away with the need for having a finishing department.

Think what this can mean in terms of expanded productivity. Space now devoted to finishing operations can be used to expand your production area. Money currently spent in equipment, maintenance and finishing supplies can be channeled to more productive use. Costs of rejects, and the insurance costs of handling explosive materials can be eliminated, too, since Clad enables you to work with *prefinished* parts.

Consider, too, what Clad can mean in greater sales potential for your product. This durable, decorative vinyl can be produced in easy-to-clean colors . . . and in plain, textured or embossed designs. And here's the beauty of Clad from a production standpoint: It can be cut, crimped, drilled and even deep-drawn, without affecting color or design . . . without distorting the material itself . . . and without the need for any special processing equipment or methods.

Truly, Masland Duran Clad merits your most serious consideration right now . . . for, make no mistake about this: *vinyl-to-metal laminates are here to stay and grow.* With production soaring from one million square feet to 18 million in just three years . . . and from 115 to 150 million square feet estimated for 1960 . . . they are obviously lowering finishing costs and increasing design flexibility in a big way.

To safeguard and improve *your* competitive position, you will find it well worthwhile to mail this coupon for more information on Masland Duran Clad . . . and the laminators serving your area.

Industrial Products Division

THE MASLAND DURALEATHER COMPANY, Dept. PE, Philadelphia 34, Pa.

Masland Duran
CLAD
vinyl finish

THE MASLAND DURALEATHER CO., Dept. PE
Amber & Willard Sts., Philadelphia 34, Pa.
Please send information and samples of Clad

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CIRCLE 149 ON READER SERVICE CARD 149

ORCO

"Customeered" components basic to industry

ideas on "Customeered" RUBBER PARTS

...their design and application for improved product performance No. 2

8-ft. rubber-metal "sandwich" resists chewing by weather, oil and millions of vehicles

Bonded-rubber component assures higher accuracy, longer operating life of vehicle detector contact unit

Pressure-sensitive detectors installed flush with roadway surfaces are vital factors in today's ever expanding vehicular world—are used for traffic control, toll collection, automatic door opening, etc.

A contact unit produced from molded-rubber bonded to heavy-gauge and thin-gauge metal strips serves as an actuator in the detectors. The pressure of a vehicle passing over the contact unit mounted on a steel frame below the surface of the road puts the detector to work—initiates a count or any specific action the detector is designed to perform.

The requirements for the sandwich-like bonded-rubber component comprising the contact unit: A completely waterproof and airtight air space within the full length of the one-foot wide units produced in varying lengths of four, six, eight and ten feet; resistance to the harmful effects of constant exposure to weather, sunlight, salt, oil and tire chains; an operating life involving a minimum of many millions of crossings by all types of vehicles.

The resulting design involved an exceptionally difficult molding and bonding job. Included were combinations of hard and soft rubbers. Careful attention had to be paid to many important and minute details of production and intricate design not only to meet the customer's stringent requirements for longer operating life but also to make good on rigid PSI specifications.

Ohio Rubber's wide and varied experience in "customeering"* to unusual specifications, as well as its broad, up-to-the-minute manufacturing facilities, were both equal to the challenge—successfully met all the requirements. The bonded, molded-rubber contact units are in regular production at Ohio Rubber.

PHOTO COURTESY AUTOMATIC SIGNAL DIVISION, EASTERN INDUSTRIES, INC.

MOLDED-RUBBER TUBE STORES AND PUMPS CLEANING FLUIDS

A most important part in the new Swirl-away Cleaner for walls, upholstery, woodwork, etc. is a molded-rubber tube which serves both as a secondary storage tank and vacuum pump for cleaning fluid. Unusual in shape and requirements the tube involved a complicated mold, close tolerances, and a control rate stock with particularly high resistance to harsh chemicals normally found in detergents. Problems on the design and production of this intricate rubber component were successfully worked out by engineers at Ohio Rubber where the part is now produced.

RUBBER-METAL PUMP IS KEY TO NEW DISHWASHER FEATURE

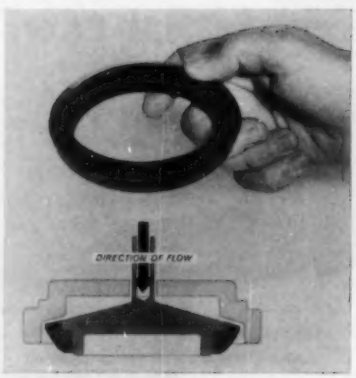
A vital component in a dual action pump which makes possible a "flush-away drain" feature in the dishwashers of a leading manufacturer, is a rubber-metal housing. Since rubber was required at several points for sealing and vibration absorption, the manufacturer asked Ohio Rubber engineers for help in designing and producing a pump housing of molded rubber bonded to a carbon-steel frame or insert. The material in the housing, which is in regular production at Ohio Rubber, also fully protects the frame from corrosive effects of both water and detergents.

THERE ARE MANY MORE EXAMPLES

of how Ohio Rubber "Customeered"* components are helping to improve product performance for outstanding original equipment manufacturers in every industry. For more information on Ohio Rubber "Customeering"*—molding, extruding, bonding-to-metal—with rubber, synthetic rubber, silicone rubber, polyurethane and flexible vinyl, write today to The Ohio Rubber Company, Willoughby, Ohio. 9DE2

**Trademarks of The Ohio Rubber Company*

Sewer-Pipe Seal – Precision extrusion of high specification rubber by ORCO provides an effective new approach for obtaining sealed or "premium joints" in sewage disposal lines—prevents surface water infiltration to reduce treatment costs. Available in a wide range of popular sizes, plus close tolerances, for concrete as well as clay pipe.



Orthane Valve Seat – Durable as the hardest steel yet resilient enough for sealing, this valve seat of molded polyurethane by ORCO is used in specialized oil field operations where it must successfully withstand the highly abrasive impact of raw crude oil mixed with gravel at pressures which often go as high as 20,000 PSI.

THE OHIO RUBBER COMPANY

Willoughby, Ohio

ORCO

A DIVISION OF THE EAGLE PICHER COMPANY

Next time your part needs special protection look to treated felts

its live fibres combine nature's best with the laboratory's latest...

They repel water, stop rust, reduce friction, resist abrasion, stand 300° F. heat or −65° F. cold. Hard or soft, their wondrous interlocking fibers go on flexing, filtering, wicking or wiping long after other materials break down.

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Naugatuck KRALASTIC

The Original ABS Resin

Coffee pot manufactured by W. & S. Blackinton Co., Meriden, Conn. Molded handle by Rogers Mfg. Co., Rockfall, Conn.

THE HANDLE IS TOUGH...THE HANDLE IS STABLE

The handle is **KRALASTIC,** of course

Toughness, strength, and dimensional stability are rapidly making KRALASTIC® an "industrial household" word as this original ABS resin continues to replace metals and other plastics for the most demanding applications.

These same properties, combined with a rich, lustrous appearance, low heat conductivity, and other desirable characteristics have proved just as valuable to the manufacturers of consumer products. As the "perfect" coffee pot handle, for example, KRALASTIC can never chip or break, will always feel comfortable to the hand. Its ease of forming by injection molding and strength in thin sections make possible unusually graceful design.

Lightweight KRALASTIC offers built-in color that sells. It can be sawed, drilled, threaded, or otherwise machined, although in most cases it completely eliminates the need for these expensive finishing operations. Where required, KRALASTIC is quickly and easily solvent welded.

Would you like to *compare* KRALASTIC in detail with the material you are presently using? The quickest way is to have your NAUGATUCK Representative call at your convenience. Or write us for full information and samples if desired.

United States Rubber

Naugatuck Chemical Division

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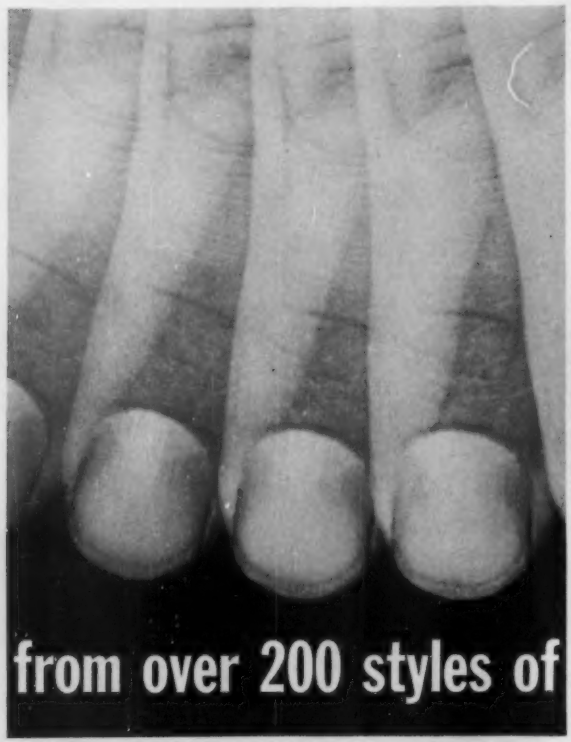
CIRCLE 153 ON READER SERVICE CARD 153

If your design includes a coated fabric... choose



from over 200 styles of REEVECOTE!

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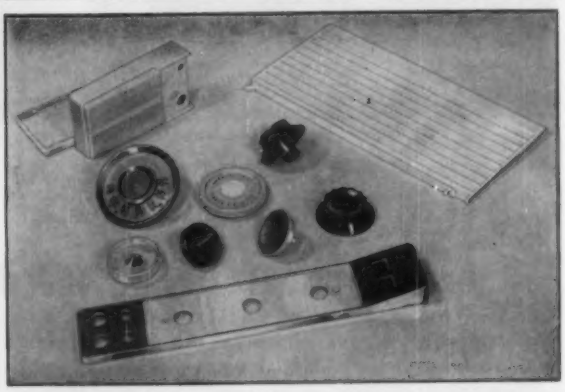
CIRCLE 616 ON READER SERVICE CARD



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CIRCLE 617 ON READER SERVICE CARD

catalogs and bulletins.....continued

(C-89) **Plastic Channel**—Brochure, 6 pp. Presents full scale cross-sections and dimensions of glass reinforced polyester insulating channel and angle. The Glastic Corp, 4321 Glenridge Rd, Cleveland 21.

(C-90) **Cellular Rubber**—Bulletin, 28 pp. Offers curves, tables and discussion covering properties of natural and synthetic expanded rubber and cellular polyvinyl chloride. B F Goodrich Sponge Products, Shelton, Conn.

(C-91) **Polyethylene**—Brochure, 20 pp. Provides a table of properties, discussion of some design considerations and pictures of typical products. W R Grace & Co, Polymer Chemicals Div, 225 Allwood Rd, Clifton, NJ.

(C-92) **Thermoplastics**—Brochure, 4 pp. Provides table of properties for four types of resins. The Foster Grant Co, Inc, Leominster, Mass.

(C-93) **Thermoplastics**—Brochure, 4 pp. Presents tables of mechanical, thermal and physical properties of four types. Foster Grant Co, Inc, 289 N Main St, Leominster, Mass.

(C-94) **Molded Acetal Resin**—Catalog, 8 pp. Discusses thoroughly properties of material. Explains company's molding capabilities. Gries Reproducer Corp, 159 Beechwood Ave, New Rochelle, NY.

(C-95) **Glass Fiber Insulation**—Brochure, 8 pp. Describes thermal and acoustical uses and characteristics of textile type insulation. Includes types and widths available. Gustin-Bacon Mfg Co, 210 West St, Kansas City, Mo.

(C-96) **Linings for Steel Containers**—Borchure, 36 pp. Describes methods of applying phenolic, vinyl and expoxy linings. Table shows compatibility with contained material. Interchemical Corp, Finishes Div, 224 McWhorton St, Newark, NJ.

(C-97) **Industrial Black Enamels**—Brochure, 4 pp. Explains uses and how to apply. Nineteen formulas described. Interchemical Corp, Finishes Div, 224 McWharton St, Newark, NJ.

(C-98) **Hand Lay-up Molding**—Brochure, 21 pp. Presents technical discussions of low temperature curing polyester resins and chemical accessories. Used also for surfacing and finishing. Interchemical Corp, Finishes Div, 224 McWharton St, Newark, NJ.

(C-99) **Press Molding Resins**—Brochure, 21 pp. Describes materials and procedures for making polyester resin premix compounds. Interchemical Corp, Finishes Div, 224 McWharton St, Newark, NJ.

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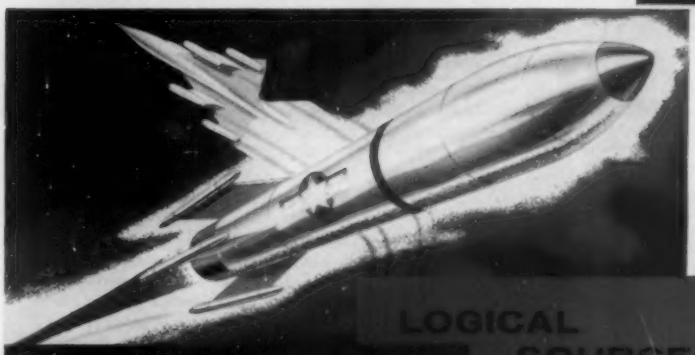

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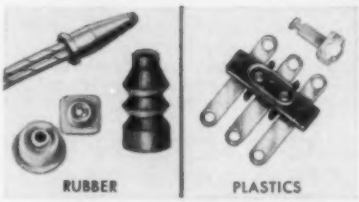

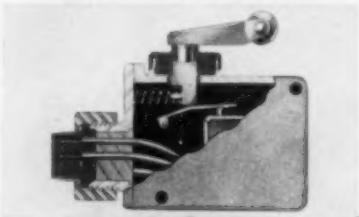

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Mass production of precision parts ranging from phase lead insulating caps of silicone rubber (shown at far left designed for room temperature vulcanizing) to switch parts of mineral-filled silicone resin (lower right, designed to retain dimensional stability at temperatures of 2000° F.) calls for precision production techniques gained only through experience.

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Environment proof limit switches (like this one for airborne equipment) call for completely sealed construction. These seals (shown in red) are silicone rubber bonded to metal by Moxness . . . evidence of Moxness ability to handle the most exacting requirements in this specialized field.

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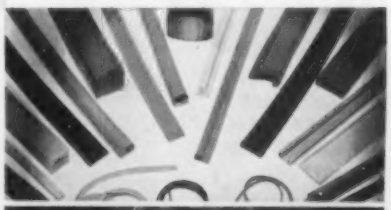

PRECISION TAPES

The coil shown here is being insulated with NEW Guide Line Triangular MOX-TAPE which provides homogeneous void-free insulation for motors (class H and B) with a single wrap. Mox-Tape fuses to itself . . . eliminates messy pastes or adhesives. Cuts taping time 50 to 60%.

*DU PONT VITON, TEFLON; 3M KEL-F

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Fiberglass reinforced plastics stimulate fresh, modern style appeal... and are exciting new sales potentials to a wide variety of consumer and industrial products. And no wonder, for the outstanding physical characteristics of this basic new material, plus its many profitable production advantages, create great interest and impact everywhere. Dimensional stability... chemical resistance... tolerance to temperature extremes... rust-proof, rot-proof, corrosion-proof... and a limitless variety of lasting colors molded-in for life... all these benefits, and many more, are to be found with Lewis reinforced polyester moldings.

More and more leading manufacturers are depending on Lewis for quality reinforced plastic moldings. Our trained engineers are ready to assist you in converting your product to this new material.

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FOR DECORATIVE COLOR... on low-cost zinc. Brilliant golds, yellows, blues, greens, violets, reds, brass and copper hues.

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CIRCLE 619 ON READER SERVICE CARD

catalogs and bulletins.....continued

(C-100) Primer or Finish—Bulletin, 5 pp. Detail uses and properties of coating that adheres to nonferrous metals, plated surfaces and plastics. Interchemical Corp, Finishes Div, 224 McWharton St, Newark, NJ.

(C-101) Plastic Molding Compounds—Brochure, 11 pp. Presents electrical physical and molding data on diallylphthalate with various fillers. Used principally for electrical and electronic components. Mesa Plastics Co, 12270 Nebraska Ave, Los Angeles 25.

(C-102) Adhesives, Coatings and Sealers—Catalog, 16 pp. Presents a comprehensive survey of characteristics, uses and properties with series of tables. Minnesota Mining & Mfg Co, Adhesives, Coatings & Sealers Div, 900 Bush Ave, St Paul 6, Minn.

(C-103) Lighted Plastic Parts—Brochure, 5 pp. Shows facilities for making and examples of molded, lighted plastic dials, pointers, light guides and others. Monroe Industries, Inc, 934 36 St SE, Grand Rapids, Mich.

(C-104) Plastics, Resins and Intermediates—Brochure, 12 pp. Describes properties and typical uses of many types. Monsanto Chemical Co, Plastics Div, Springfield, Mass.

(C-105) Carbon-graphite—Catalog, 12 pp. Presents compositions, properties and examples of applications such as bearings, seals and steam gland rings. Morganite, Inc, 33102 48 Ave, L I City 1, NY.

(C-106) Structural Adhesives, Laminates—Catalog, 6 pp. Presents properties, applications of adhesives, adhesive impregnated fabric, laminating material, putties, resins, aluminum and glass fiber sandwich core material. Narmco Materials Div, Narmco Industries, Inc, 600 Victoria St, Costa Mesa, Cal.

(C-107) Electronics, Plastics and Ceramics—Brochure, 10 pp. Presents tables of properties and shows representative uses of compounds for castings, coatings, adhesives, laminates, encapsulents, impregnating. Emerson & Cuming, Inc, Canton, Mass.

(C-108) Plastic Laminates—Brochure, 4 pp. Gives properties of laminates with glass fabric, paper, canvas or cotton base materials impregnated with epoxy or phenolic resins. Includes copper clad laminates. New England Laminates Co, Inc, Box 43, Stamford, Conn.

(C-109) Faced Plywood—Brochure, 6 pp. Discusses mechanical properties of plastic or metal faced sandwich panels. US Plywood, 55 W 44 St, NYC 36.

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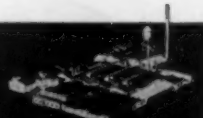

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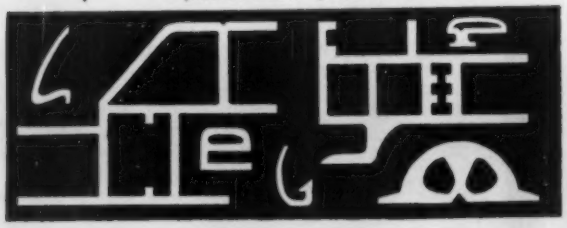

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CIRCLE 622 ON READER SERVICE CARD

catalogs and bulletins.....continued

(C-110) Injection Molding—Brochure, 12 pp. Outlines scope of service for producing molded plastic parts. Nosco Plastics, Inc, Box 269, Erie, Pa.

(C-111) Carbon-graphite—Brochure, 8 pp. Presents mechanical and thermal properties of different grades. Suggests applications of the molded product such as valve seats, seals, piston rings. The Ohio Carbon Co, 12508 Berea Rd, Cleveland 11.

(C-112) Foamed Plastic—Brochure, 16 pp. Furnishes descriptions and graphs of physical and chemical properties for urethane plastics. Nopco Chemical Co, Plastics Div, 175 Schuyler Ave, N Arlington, NJ.

(C-113) Cast Polyethylene Film—Bulletin, 12 pp. Describes film casting equipment, cast film properties, effects of process variables on properties, choice of resins. US Industrial Chemicals Co, Div of National Distillers & Chemical Corp, 99 Park Ave, NYC 16.

(C-114) Friction Materials—Brochure, 48 pp. Through curves and tables describes behavior of clutch facing and brake lining materials in molded, woven, sintered metal, metal ceramic forms. Raybestos-Manhattan, Inc, Equipment Sales Div, Box 1021, Bridgeport, Conn.

(C-115) Reinforced Plastic—Brochure, 12 pp. Discusses properties of asbestos reinforced thermosetting plastics for laminating, molding and machining. Raybestos-Manhattan, Equipment Sales Div, Box 1021, Bridgeport, Conn.

(C-116) Teflon Rod, Sheet and Tube—Brochure, 4 pp. Lists properties of material and sizes available. Resistoflex Corp, Woodland Rd, Roseland, NJ.

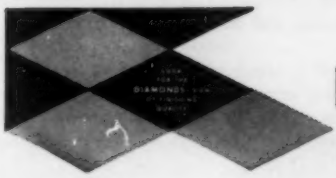
(C-117) Laminated Plastics—Brochure, 8 pp. Provides sizes, physical, electrical and special properties of laminated sheet, tube, rod. The Richardson Co, 2793 Lake St, Melrose Park, Ill.

(C-118) Nonmetals—Brochure, 4 pp. Presents chart of properties, uses, fabricating methods for plastic, rubber and cellulose materials for electrical insulation, gaskets and seals. Rogers Corp, Rogers, Conn.

(C-119) Molded Plastic—Brochure, 4 pp. Explains molding service and stock shapes available. Provides table of TFE fluorocarbon characteristics. Sparta Mfg Co, Div of US Ceramic Tile Co, Box 107, Dover, Ohio.

(C-120) Electronic Plastic Laminates—Brochure, 4 pp. Charts properties of paper and glass base phenolic and epoxy laminates. Also copper clad laminates. Spaulding Fibre Co, Inc, 310 Wheeler St, Tonawanda, NY.

continued



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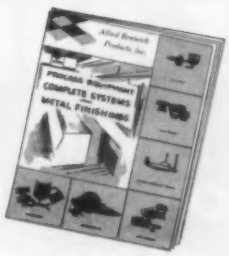

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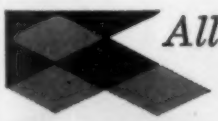

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(C-121) **Graphite**—Brochure, 8 pp. Tabulates engineering data, illustrates some uses and points out design practice. Speer Carbon Co, St Marys, Pa.

(C-122) **Carbon Graphite**—Catalog, 53 pp. Discusses the material's properties as well as specific mechanical, chemical, electrical and refractory uses. Stackpole Carbon Co, Stackpole St, St Marys, Pa.

(C-123) **Plastisols and Organosols**—Brochure, 6 pp. Describes composition of compounds. Explains several methods of application such as slush molding, clip coating, cavity molding, spraying, cloth coating. The Stanley Chemical Co, 75 Berlin St, E Berlin, Conn.

(C-124) **Rubber**—Data folder, 6 pp. Discusses properties of natural rubber, silicone rubber, buna-n, butyl, SBR and two other copolymers. Stillman Rubber Co, 5813 Marilyn Ave, Culver City, Cal.

(C-125) **Rubber Products**—Catalog, 11 pp. Shows molding, bonding, extrusion, calendering methods; vibration mount, diaphragm products and others. Stoner Rubber Co, Inc, 10792 Knott Ave, Anaheim, Cal.

(C-126) **Laminated Plastics**—Bulletin, 18 pp. Contains properties chart for 21 laminates plus discussion of characteristics and how to specify. Taylor Fibre Co, Norristown, Pa.

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SECTION D

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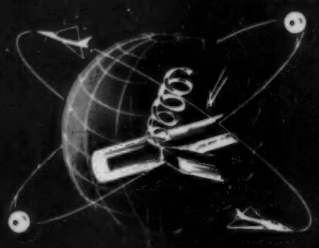


Design Abstracts 162

9 Heat-forming Techniques for Plastic Sheet
by R. E. Kostur 164

9 Typical Coil Designs for Induction Soldering and Brazing 168

12 Ways to Work Titanium
by J. M. Wentzell 169

Matching the Burner to the Job is Key to Better Flame Hardening
by B. G. Ward, Jr. 171

Design Hints on Electroforming
by Bruce Chandler Jones 174

DESIGN ABSTRACTS

ELECTRICAL-DISCHARGE MACHINING

Electrical-discharge machining is a relative newcomer in the science of metal removal. Its effects on metallurgy have not been completely resolved. Related to the metallurgical effects is a possible clarification of the underlying principles of its basic mechanism of metal removal. Little information has been reported on the effects of an electrical-discharge-machined surface on the mechanical and chemical properties of the workpiece material. There is a need for quick and inexpensive electrodes. This paper presents the research and development work that has been conducted at the Grumman Aircraft Engineering Corporation in an attempt to resolve some of these problems.

"Recent Developments in the Theory and Application of Electrical-discharging Machining," George G. Bott, Grumman Aircraft Engineering Corporation. ASTE Technical Paper Number 220, American Society of Tool Engineers, 10700 Puritan Ave, Detroit 38, Michigan.

*

Machining Glass-plastics

Practical production methods for glass-plastics laminates are described and assessed for their utility.

"Techniques for Machining Glass-plastics Laminates," E. C. Graesser, National Vulcanized Fibre Co, Wilmington, Del. Plastics Technology, November, 1959, 630 Third Ave, New York 17, New York.

*

Extruding Polyethylene

The utilization of high density polyethylene profiles and tubing has just begun to be exploited in areas where stiffness, toughness, abrasion resistance and chemical inertness properties are required. Advantages are also gained in reduction of material costs per foot of extension due to the lower price per pound of high density polyethylene resin vs nylon or butyrate resins. A cost savings is also available with high density polyethylene vs. rigid polyvinyl chloride. An approximate 12% increase in yield of extruded product is obtainable due to the lower density of linear polyethylene compared with polyvinyl chloride. Covered, are die design, extrusion conditions, and post handling.

"The Extrusion of High Density Polyethylene Tubing and Profiles," D. J. Schmidt, W. R. Grace & Co. SPE Journal, May 1960, 65 Prospect St, Stamford, Conn.

*

Applying Ultrason During Casting

Experiments are described in which grain refinements was achieved in large cast structures by ultrasonic vibration during solidification.

"Uses of Ultrasonics on Grain Growth During Casting," D. H. Lane, Westinghouse Materials Laboratories, Pittsburgh.

*

Design of Forgings

Presents the basic principles of forging and shows how the designer can apply them most satisfactorily. A table of drop-forging thickness, surface and offset tolerances is included along with 8 illustrated examples of principles.

"Design Principles of Forging," R. C. Jones, Head Wrightson Stampings Ltd., Engineering Materials and Design, March '60, Drury House, Russell St, London, WC 2, England.

*

Barrel Finishing

The article discusses the two primary types of deburring compounds—those with and those without abrasive grains. It discusses the effects of particle size and how the particles are reduced in size during the barrel finishing. Also discussed are uniformity of size and toughness of the grains, and relative advantages and disadvantages of various types of grain.

Actually, there is no "ideal" compound since there is such a wide variety of problems encountered in barrel finishing. A compound should be considered as a "tool" and not some miraculous thing that somehow knows what results are wanted and automatically produces the desired end result. There are numerous compounds available for deburring from a number of supply houses specializing in material for barrel finishing.

"Abrasive Compounds in Barrell Finishing," Arthur S. Kohler, Frederick Gumm Chemical Co, Kearney, NJ, Plating, Jan '60, 445 Broad St, Newark 2, NJ.

*

High-speed Machining

Missiles and high-performance aircraft require alloys to withstand high temperatures while retaining high strength for structural integrity. But these alloys are difficult to machine by conventional methods. This paper reviews a method that removes metal with an ultra high-speed machining projectile.

"Recent Developments in Ultra High-speed Machining," Robert L. Vaughn, Lockheed Aircraft Corp, and Robert T. Krueck, Wright-Patterson Air Force Base. ASTME technical paper, American Society of Tool and Manufacturing Engineers, 10700 Puritan Ave, Detroit 38, Michigan.

*

The Modern Arc Torch

In late 1955, the modern plasma jet was introduced to industry for the cutting of aluminum; since then, this country has had a boom in plasma jets. Because of plasma jets, the electric arc has now gained a scientific status unparalleled in its 150-year history. With reference to the term "plasma jet"—any high-current arc is comprised of plasma which is nothing more than ionized, conducting gas. When this plasma gas is jetted through a nozzle, it becomes a "plasma jet."

"The Principles of the Modern Arc Torch," R. M. Gage, Linde Co, Welding Journal, October 1959, 33 W 39 St, New York 18.

*

Explosive Forming

While this process presents certain problems, such as the dangers involved in explosives handling, the selection of a safe blasting area, and the danger of failure of the forming die through the use of too large an explosive charge, it also has many advantages. The energy available for forming is almost unlimited; all we need do to get more energy is to use more explosives.

The size of the parts which can be

shaped is limited only by the availablity of sufficiently large blanks of materials, as no mechanical presses are required. The pressures which can be produced by far exceed those which could be generated by any conceivable mechanical forming press. In addition to these advantages, there are some not quite so obvious, which may be of equal or even greater importance.

"Recent Developments in Explosive Forming at Grumman Aircraft," Arthur Wickesser, Jr., Grumman Aircraft Engineering Corp. ASTE Technical Paper number 229, American Society of Tool Engineers, 10700 Puritan Ave, Detroit 38, Michigan.

*

Design of Forgings

Forging is a technique that can produce high strength and other special characteristics in a component. This article presents the basic principles of forging and shows how the designer can apply them most satisfactorily. A table of drop forging thickness, surface and offset tolerances is included along with 8 illustarted examples of principles.

"Design Principles of Forgings," R. C. Jones, Head Wrightson Stampings Ltd. Engineering Materials and Design, March 1960, Drury House, Russell St, London, W.C. 2, England.

*

Determining Weld Size

Various types of welds are discussed as well as the kinds of loads frequently imposed on them. Standard formulas to find force exerted on a weld are included, as well as a planned procedure for applying to specific design problems. Curves, tables and nomograms are included.

"Practical Approach to Determine Weld Size," O. W. Blodgett, Lincoln Electric Co. Welding Journal, Aug 1959, 33 W 39 St, New York 18.

*

High-speed Machining

Missiles and high-performance aircraft require alloys to withstand high temperatures while retaining high strength for structural integrity. But these alloys are difficult to machine by conventional methods. This paper reviews a method that removes metal with an ultrahigh-speed machining projectile.

"Recent Developments in Ultrahigh-speed Machining," Robert L. Vaughn, Lockheed Aircraft Corp, and Robert T. Krueck, Wright-Patterson Air Force Base. ASTME technical paper, American Society of Tool and Manufacturing Engineers, 10700 Puritan Ave., Detroit 38.

*

Vacuum Metallizing Plastics

The equipment, the process and various vacuum metallized finshes for plastics are described. Special considerations applying to various types of plastics are also briefiy discussed.

"Vacuum Metallizing as Related to Plastics," T. J. LaBounty, Midwest Technical Services, SPE paper 13-1. Society of Plastics Engineers Inc, 65 Prospect St, Stamford, Conn.

*

Continuous Blow-forming of Extruded Tubing

Polyethylene tubing is extruded up and through pinch rolls and guide plates which control inflation to produce variations in diameter up to 10 times that of uninflated tube. Typical blown shapes are illustrated, as well as takeoff and forming mechanism. Principles and limitations are discussed.

"Continuous Blow-forming of Extruded Tubing," T Kasahara, Polymer Industrial Co, Ltd, Tokyo, Japan. Modern Plastics, Aug 1959, 575 Madison Ave, New York 22.

*

Chemically Milled Parts

This paper describes the chemical milling briefly, and in more detail outlines the primary applications, design, information, and standard practices.

"Design Consideration of Chemically Milled Parts," by L. Chandler, Plant Superintendent, Anadite, Inc. Presented at the Nineteenth National Conference of the S.A.W.E., May 17, 1960. Society of Aeronautical Weight Engineers, Inc, c/o Douglas Aircraft Co, El Segundo, California.

*

Machining With Ceramic Tools

One of the chief advantages of ceramic cutting tools is that machining time can be reduced because of higher cutting speeds attainable. Test results compare the performance of ceramic tools and carbide tools when machining cast iron.

"Machining Cast Iron With Ceramic Tools," J. L. Remmerswaal, Metal Research Institute T.N.O., Delft, The Netherlands. The Tool Engineer, February 1960, 10700 Puritan Avenue, Detroit 38, Michigan.

*

Color—Paint or Mold-in?

Economics and relation quality of finishes for coloring molded plastics integrally vs painting in a separate process are discussed. Included are basic calculations and tables giving comparative costs for general-purpose polystyrene.

"Painting vs Molding in Color," T. E. Hayden, Bee Chemical Co; SPE Journal, Jan '60, 65 Prospect St, Stamford, Conn.

*

Shop Noise

Measurement and description of shop noise, acceptable sound levels, main noise sources in equipment and small plants and corrective action are discussed. Includes bibliography of related articles.

"Keeping Shop Noise from Nearby Residences," H. C. Hardy, Howard C. Hardy Associates. Available without charge from Small Business Administration, Washington 25, D. C.

*

Evaluating Results of Accelerated Tests

Mathematical criteria are developed that indicate the conditions under which reliability data obtained from accelerated tests can be used to predict reliability in normal use. In addition, a simple model-prototype relation is developed that is suitable for application to accelerated test programs when environmental stresses are negligible.

"Accelerated Testing as a Problem of Modeling." Gary and Thomas Battelle Memorial Institute. Presented at Sixth National Symposium on Reliability and Quality Control in Electronics, Jan 11-13, 1960. Battelle Memorial Institute, Columbus 1, Ohio.

From: SPE paper

9 HEAT-FORMING TECHNIQUES for Plastic Sheet

Vacuum and drape forming are basic methods. These, along with refinements such as plug assist, vacuum snap-back, billow forming and others that speed results are here surveyed.

R. E. KOSTUR
Vice President
Comet Industries

Fast moving developments in materials for thermo sheet forming and the continuous refinement of equipment for it, tend to obscure a basic problem in the field. Because of confusion and misunderstanding of the forming techniques, it is becoming more difficult to obtain satisfactory and economical thermo-formed parts.

The introduction of new materials for the industry has brought about new forming techniques in order to fabricate successfully and economically. These techniques utilize predrawing or redrawing of the plastic during the forming operation; basically the name of compound forming was given to deep drawing of metal parts in the metal stamping industry. When drawing metal, a series of dies are used to produce preshapes from metal. These shapes are then annealed and redrawn until the metal has stretched to its required depth.

Fortunately with the drawing of plastic sheets, a series of draw operations are not required as in the metal industry. Nevertheless, in deep drawing of plastic sheet predraws are also required in order to control wall thickness, reduce blank size and reduce orientation of the fabricated part.

In the following diagrams these various operations for the convenience of discussion are laid out one by one, but spreading them out in this way is an artificial approach because they are so interrelated, they should be considered together.

In the following methods, it is assumed that the plastic has been evenly heated and its method of ejection from the mold will be by air pressure and mechanical means.

VACUUM FORMING INTO A CAVITY

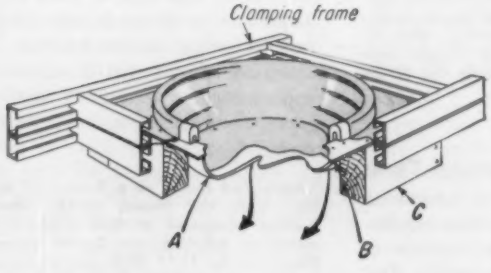
The heated sheet is draped over the mold cavity, Fig. 1, sealing off the mold edge B. With the application of vacuum from the under side of the sheet, the plastic is drawn into a mold cavity A. The surface area over the mold cavity contains a given number of square inches of material which will be stretched to occupy the number of square inches in the mold cavity for the required thickness.

Draw Ratio

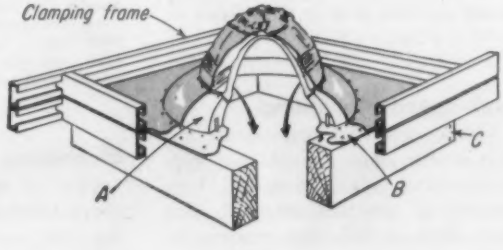
The ratio between these two products represents the draw ratio. The draw ratio may be calculated by this same method in other forming techniques.

DRAPE FORMING

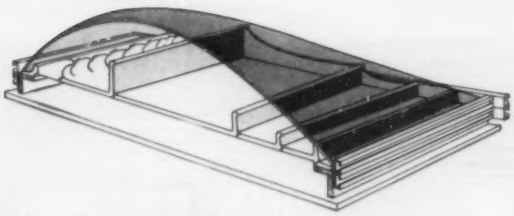
Drape forming, Fig. 2, offers better material distribution as compared to cavity forming. A larger surface area of plastic is available for distribution over the mold, consequently the draw ratio is also reduced. By draping the plastic over the male mold, it is stretched into a preshape, resulting in additional material for mold coverage. The thickness of the material is reduced, however wall thickness is more uniform.



1. . VACUUM FORMING



2. . DRAPE FORMING



3. . INVERTED DRAPE FORMING

INVERTED DRAPE FORMING

Inverted drape forming, Fig. 3, is widely used on parts that require plug assists. This method eliminates the plug mark-off or surface defects due to plug contact. As seen, the plastic sheet is slightly overheated, resulting in a large sagging condition of the sheet. This preshape reduces the draw ratio allowing sufficient material to fill the corners and cavities of the mold.

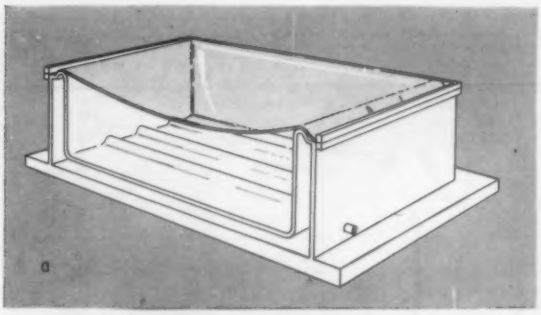
PLUG ASSIST

Plug assist forming, Fig. 4, is a combination of a cavity and drape forming. It prevents excessive thinning of material when formed into deep mold cavities. A heated plug 120 to 180F is used to position the material into the mold. Distribution of the material is dependent upon the distance that the plug enters the mold. Too deep a plug stroke results in unstretched material at the bottom of the form and thin side walls. If the plug stroke is not deep enough, a paper thin bottom will result as well as thin corners. By controlling the plug stroke, material distribution is also controlled. Clearance between plug and mold is not critical, usually one-fifth the depth of draw is sufficient. Plug assist forming does require some caution in that plug mark-off is sometimes difficult to eliminate. Orientation of the side walls is also evident when plugging the plastic into deep molds.

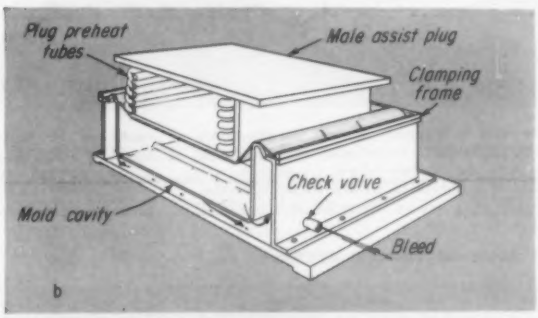
VACUUM SNAP BACK

The reduction in blank size which is offered by this process, Fig. 5, as well as control and uniformity of material distribution has made it one of the most popular techniques in use today.

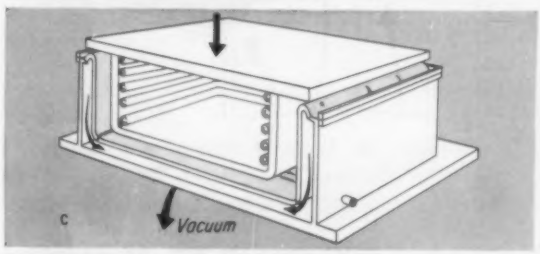
4. . PLUG ASSIST



The mold cavity is draped against the sheet, sealing off at the mold periphery and clamping frame.

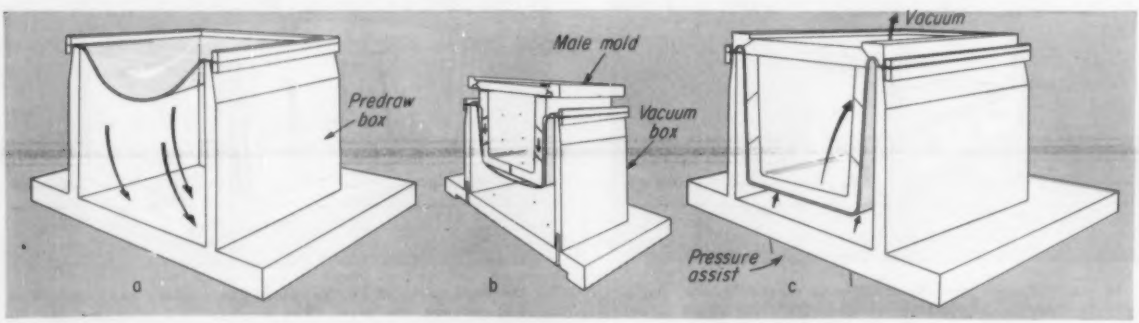


As the plug descends pushing the material into the cavity, excessive air pressure is released through the check valve.



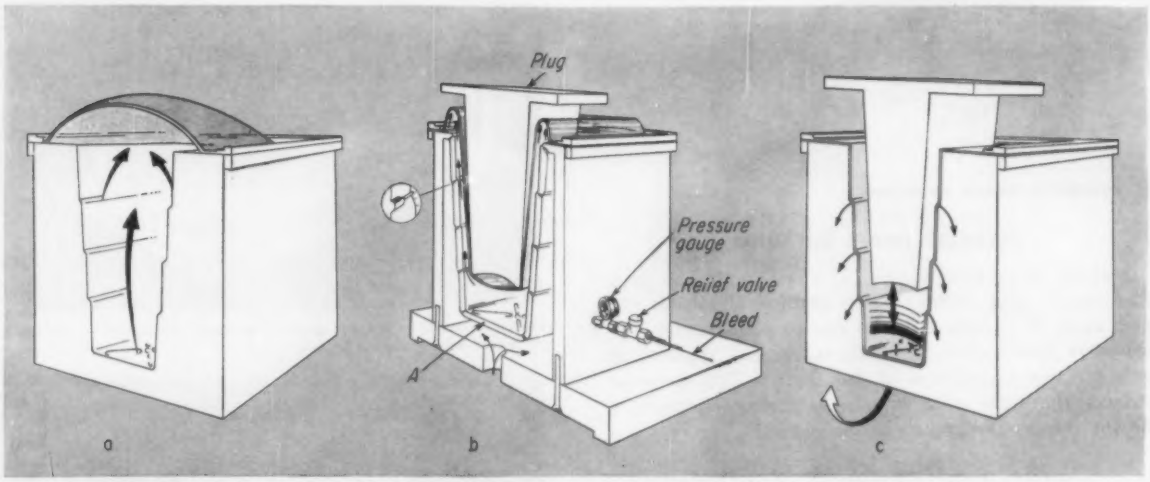
When the plug has reached the proper depth, vacuum is then applied through the mold, pulling the plastic from the plug and snapping it against the mold cavity.

5. . VACUUM SNAP-BACK



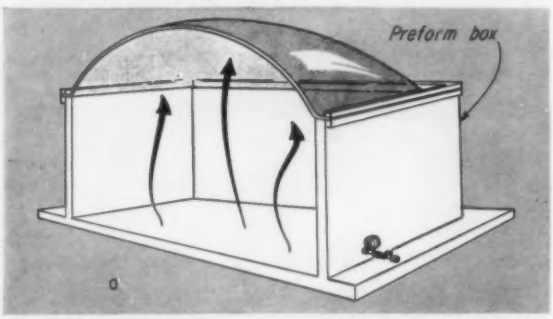
The predraw box is "draped" against the plastic sheet. Vacuum then sucks the predraw to the proper depth. When reaching the desired depth, the male mold enters the vacuum box, sealing off on the box. Vacuum is then reversed from the predraw side to the mold. As vacuum shapes the plastic over the mold, air pressure is introduced to increase the pressure on the surface of the sheet and to release the vacuum lock. The vacuum box is then lowered, exposing the fabricated part to the cooling fans.

6. BILLOW FORMING

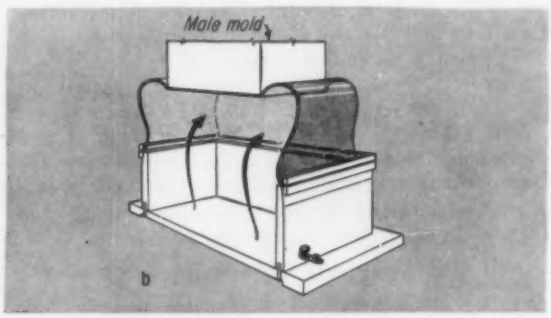


The mold is "draped" against the sheet. Air is automatically introduced into the mold through the vacuum holes, pressurizing the mold to a regulated setting of air pressure. As the plug enters the mold at a constant speed of 15 in. per second, the sudden surge of air pressure causes the plastic to billow up, thus following the plug into the mold, never touching the mold edge. The pressure is held constant by a relief check valve which is attached to each mold cavity. At the end of the plug stroke, vacuum is automatically applied, fabricating the plastic to the contour of the mold. The plug is then removed to speed the cooling cycle.

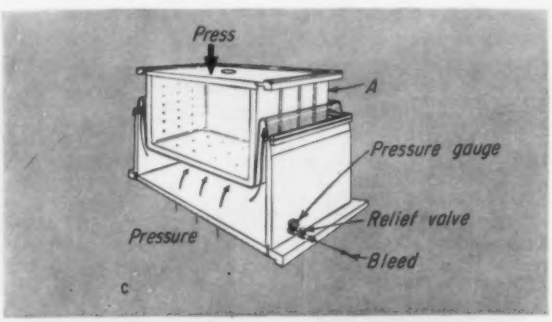
7. BLOW-UP VACUUM REVERSE



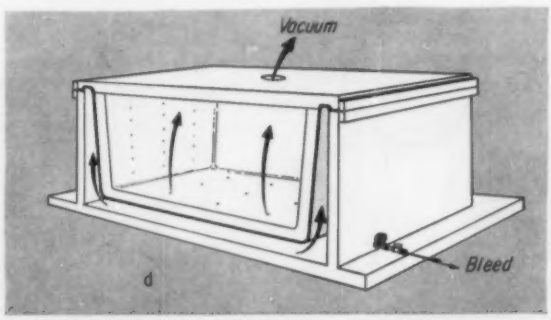
The predraw box is draped against the sheet. Air is introduced for blowing of the bubble.



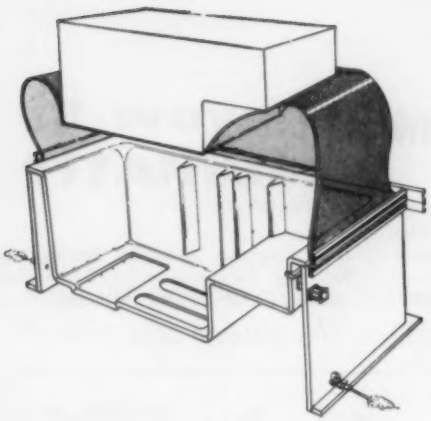
If thin side walls and a heavy bottom are desired, the mold may be used to prevent the material from thinning on the section representing the bottom of the formed part.



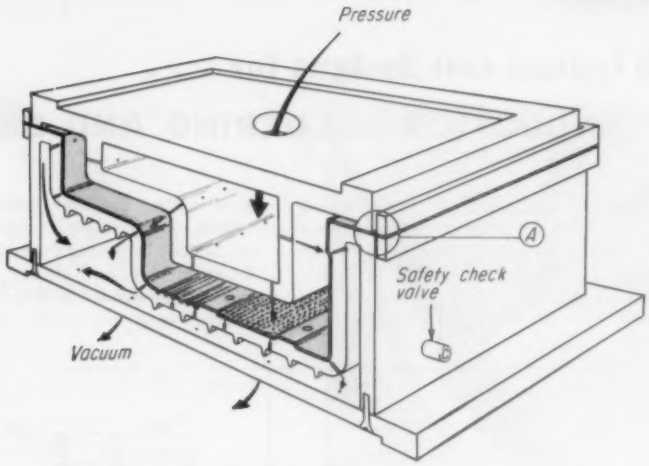
As the mold plunges into the air formed plastic bubble, the air supply is stopped. The plastic reverses its draw which is supported by the pressure controlled exhausting air. The exhausted air is controlled by a pressure regulated valve in order to allow sufficient air pressure to remain in the bubble for additional stretching of the plastic.



As the mold seals off on the top of the predraw box, vacuum is applied through the mold. The predraw box is then removed, exposing the plastic to the cooling fans. It is important to know the blank size and draw ratio for blow-up vacuum reverse. Clearance between mold cavity and clamp frame is usually gaged as 12% of the width of the part.



8. . BLOW-UP VACUUM REVERSE INTO CAVITY



9. . MALE-ASSIST PRESSURE FORMING

Uniformity of material distribution is accomplished by the predrawing of plastic into an open end box by use of vacuum, resulting in the predraw. The depth of predraw affects material distribution of the side walls and bottom thickness.

Inverted snap back is accomplished by mounting the predraw box on top and allowing the heated sheet to sag before drawing it up into the predraw. This technique is useful when working with materials that sag appreciably.

BILLOW FORMING

In the process of billow forming, Fig. 6, the prestretching of the plastic is achieved by a pressure regulator column of air resulting from the entrance of a heated plug into a pressurized female mold.

Cushion Forming

By blowing air through the punch and through the mold, Fig. 6C, a cushion of air supports the plastic from two sides. This is commonly called cushion forming.

BLOW-UP VACUUM REVERSE

This technique exaggerates the use of predraws by blowing up of a plastic bubble, Fig. 7. The height is usually 50 to 75% of the mold depth.

How to determine blank size and draw ratio for blow up vacuum reverse.

The blown bubble prestretches the plastic to uniform thickness, or the thickness of the material of the height of the bubble is equal to the thickness of the bottom of the finished part. Clearance between mold cavity and clamp frame is usually gaged as 12% of the width of the part.

Width of the part is 23 in. x 12%–2 to ¾ in.

Usually ¾ in. is required for clamping and mold clearance.

Formed part 48 in. x 23 in. x 20 in. deep.

Blank size is 55 in. x 30 in.

Blank thickness is figured "area equivalent" in ratio to the area to be covered. Expect to get 100% use of center area, and 50% of the surplus area.

Center area 48 x 23 = 1104 sq in.	1104
Surplus area (53.5 x 28.5)–1104/2	421
"Area-equivelent" total	1525 sq in.

The finished part represents 3944 sq in.

The ratio of part to "area equivalent" of stock is 3944:1525 or 2.5 ratio

The finished part requires a thickness of 0.090

0.090 x 2.5 = 0.225

The above part requires a blank 55 in. x 30 in. x 0.0225 thickness.

BLOW-UP VACUUM REVERSE INTO CAVITY

This process is relatively the same as the technique previously explained, except that the vacuum is applied from the bottom platen and the plug is heated to prevent mark-off, Fig. 8.

MALE ASSIST PRESSURE FORMING

Pressure forming, Fig. 9, is used to fabricate plastic at lower temperatures or to reproduce mold surface textures.

General

The term "drape" is used throughout this article with relation to the vertical movement of the mold through or against the heated plastic sheet. The mold may be draped against the plastic as on machinery with movable mold platens; or the plastic may be draped over a mold as with the drape type clamp frame.

The essence of thermoforming is getting the correct relationship of machinery functions, material characteristics, performance, and above all the understanding of balancing all of these.

REFERENCE:

Summary of Thermoforming Techniques by R. E. Kostur, Comet Industries, Franklin Park, Illinois. Paper presented at the Sixteenth Annual Technical Conference of the Society of Plastics Engineers, Inc, Chicago, Illinois, Jan. 1960.

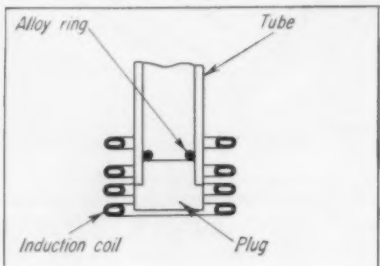
From: Company Bulletin

9 typical coil designs for . . .
INDUCTION SOLDERING AND BRAZING

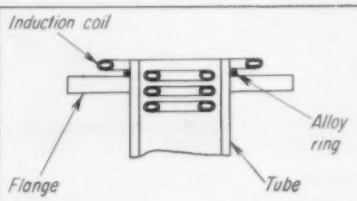
For best results, preforms of the brazing alloy should not form closed loops when subject to inductive coupling from the work coil. Also, it is desirable to electromagnetically shield the replaced alloy with the components to be joined to avoid melting the alloy before the joint surfaces are at joining temperature. This can be done by placing the preforms inside the assembly, as in 1, 4, and 7; or by recessing a component as in 6. Frequently, chamfers or grooves can be incorporated.

REFERENCE:

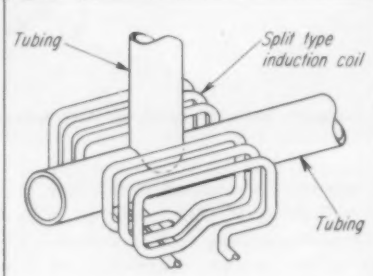
High Frequency Induction Brazing and Soldering. Published by Lepel High Frequency Laboratories, Inc, Woodside, New York.



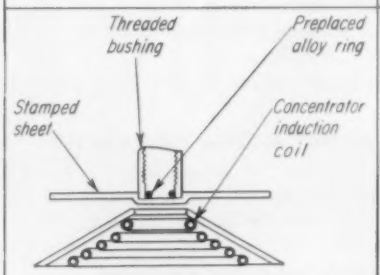
1. PLUG-TO-TUBE joint. Turns of solenoid coil may be spaced for suitable heat pattern depending upon the materials being joined. Tight fit is desirable.



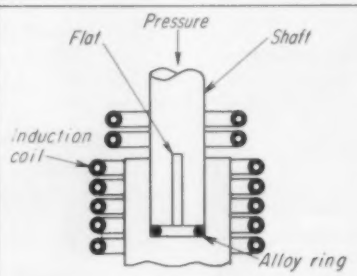
2. FLANGE-TO-TUBE joint required internal-external coil. Flange is chamfered to hold preplaced alloy.



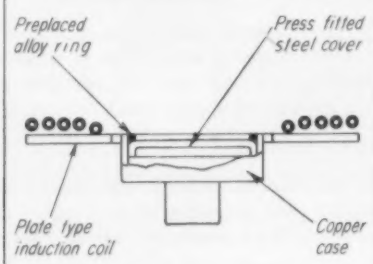
3. TUBE-TO-TUBE T joint in split solenoid coil. Alloy ring preplaced internally to provide uniform fillet without excess joining alloy along the sides of the tube.



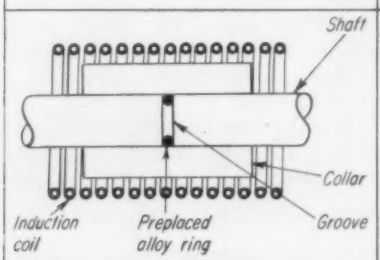
4. THREADED BUSHING joined to metal stamping. Concentrator coil localizes heat, alloy is preplaced at base of bushing.



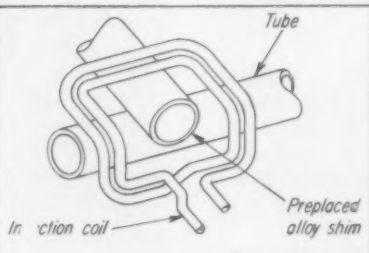
5. SHAFT to fitting joint. Solenoid coil has varying diameter. Alloy is preplaced internally at base of recess, pressure is used to seat shaft—small flat lets gas escape.



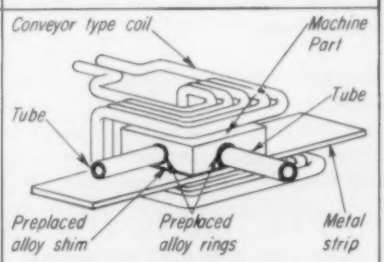
6. ASSEMBLY of formed metal shapes. Plate coil for localized heating—alloy preform is partially shielded from electromagnetic field by case.



7. SHAFT-TO-COLLAR joint. Solenoid coil with alloy ring preplaced in machined groove, which is inside assembly.



8. TUBE-TO-TUBE joint. L-shaped pancake coil is used. The alloy shim is placed between the tubes.



9. ASSEMBLY of components. Conveyor type coil—alloy shim preplaced between machine part and metal strip.

From: Design Engineering

12 ways to work TITANIUM

Basic information on how the metal should be machined, formed, heat treated, and welded.

J. M. WENTZELL
Technical Service Director
Atlas Titanium Ltd.
Welland, Ont, Canada

Titanium can be supplied in all standard wrought forms. It can be rolled, hammered, pressed or extruded from ingots into blooms, billets or slabs, and then worked into forging billets, plate, sheet, strip, bars, rods and wire. Successful fabrication of these raw-material forms into end products such as titanium-tipped plating racks, marine structures, and aircraft engine-pods is dependent upon the type of tooling employed, the forming temperature in relation to the severity of the part to be formed and, most of all, an understanding of limitations peculiar to the metal. Here is basic information on 12 methods for working with titanium.

MACHINING

Production results have indicated that commercially pure titanium machines similarly to 18-8 stainless steel. The alloy grades machine somewhat more difficult but do not approach the hard-to-machine high temperature alloys.

Turning

Commercially pure and alloyed titanium can be turned with little difficulty. Carbide tools are the most satisfactory for turning titanium. Cast alloy tools may be used when carbide is not available and when the cheaper high speed steels are not satisfactory.

Milling

The milling of titanium is a more difficult operation than that of turning. The cutter mills only part of each revolution. During the portion of the revolution that each tooth does not cut, the titanium chip remains tightly welded to the tooth's edge.

This problem can be alleviated to a great extent by employing climb, instead of conventional, milling. In this type of milling, the cutter is in contact with the thinnest portion of the chip as it leaves the cut.

For slab milling the work should move in the same direction as the cutting teeth; and for face milling the teeth should emerge from the cut in the same direction as the work is fed.

In milling titanium the cutting edge usually fails because of chipping, thus the results with carbide tools are often less satisfactory than with cast-alloy tools. A water base coolant is recommended.

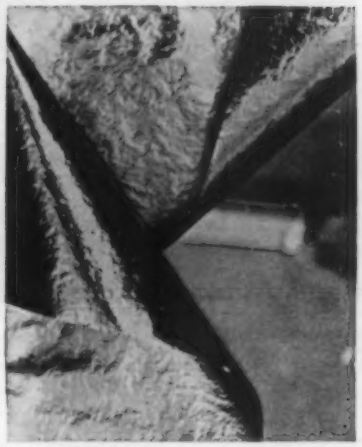
Drilling

Successful drilling can be done with ordinary high speed steel drills. One of the most important factors in drilling titanium is the length of the unsupported section of the drill. This portion of the drill should be no longer than necessary to drill the required depth of hole and still allow the chips to flow unhampered through the flutes and out of the hole.

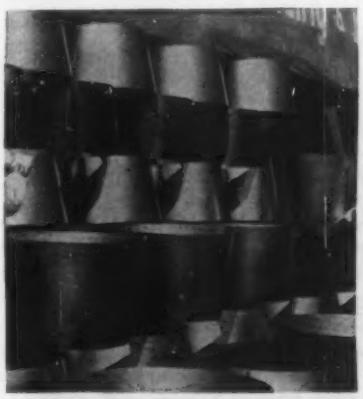
Tapping

Tapping titanium is one of the more difficult machining operations. Most of the success in tapping has been with a 65% thread.

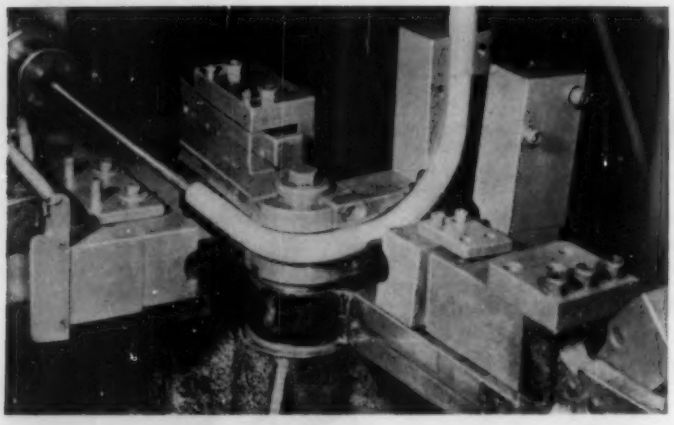
Chip removal is one of the serious problems in tapping. However, in tapping through holes, this problem is simplified by using a gun-type tap; the chips are then pushed ahead of the tap. Another problem is the smear of titanium on the land of the tap, thereby resulting in the tap freezing or binding in the hole. An active cutting oil such as a sulferized and chlorinated oil is helpful in avoiding this.



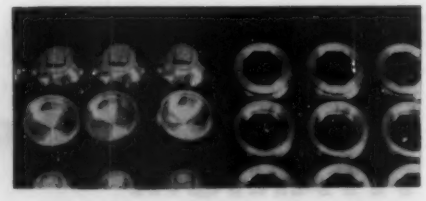
TITANIUM-FOIL is available in widths up to 24 in. and in commercial thicknesses ranging from 0.000125-in. to 0.010-in. Titanium foil has potentialities in the electronic industry and in honeycomb sections. (All photos courtesy of Union Carbide Co.)



WELDING light gauge titanium can be done in the thickness range of 0.020-in. to 0.075 in. These cones, later processed into afterburner assemblies for jet planes are made of 0.040-in. thick titanium.



IMPROVED TECHNIQUES now make it possible to cold-bend titanium tubing on a radius as small as its own diameter at costs comparable with those for stainless steel. Springback should be found by test bends before final setup.



POWDER METAL titanium-base alloy valve plugs and valve seats. Since close tolerances can be held, machining is eliminated on all non-contacting surfaces. For machining use the same methods as those for the pure metal.

Grinding

A proper choice of grinding fluid, abrasive wheel and low wheel speeds can expedite this form of shaping titanium. The procedure recommended is to use considerably lower wheel speeds than in conventional grinding of steels. Indications are that titanium can be ground more easily than high speed steels.

FABRICATION

Forming sheet material is accomplished by four basic methods: hydropress, brake, stretch forming and drop hammer. In forming a titanium part, the first step is preparation of the blank. This operation is very similar to that used for 18-8 stainless steel. Shearing, die blanking, nibbling and sawing are all satisfactory.

Deburr the titanium blank edge before forming because of the relative notch sensitivity of titanium. The deburring operation actually should produce a round polished edge.

Hydraulic Press Forming

Rubber pad hydropress forming can be accomplished either hot or cold depending on the type tooling employed and the press pressures used. This type of forming is used on parts that are predominantly flat with flanges, beads and lightening holes.

Power Brake Forming

Brake forming is used to form angles, Z-sections, hat sections, and channels. In practice, the sheet metal blank is placed over a trough die and the angle formed by forcing the sheet into the trough with a male die. The minimum bend radius for brake forming of commercially pure titanium should not be less than 3T. The best results are obtained by brake forming between 400 to 600 F.

Stretch Forming

Stretch forming has been used on titanium primarily to bend angles, hat sections, Z-sections and channels and to form skins. This type of forming is accomplished by gripping the section to be formed in knurled jaws, loading until plastic deformation begins, then wrapping the part around a male die. Loading of the part of sheet until plastic deformation begins and wrapping around the die should be done at a very slow rate. Springback is equivalent to that of one quarter hard 18-8 stainless steel. All blanks for stretch forming should have the edges polished to remove any notch effects.

Drop Hammer Forming

In drop hammer forming, the best results have been obtained by warming the female die to 200-300 F to remove the chill and heating the blank to 800-1000 F for 10 to 15 minutes. The part is then struck and set in the die. No further finishing is needed.

Heat Treatment

The only heat treatment necessary on commercially pure titanium is a stress relief operation. The received material is in the annealed condition, its most workable form. A stress relief treatment is necessary to relieve residual stresses imposed during forming. Stress relieving may be accomplished by heating at 700-1000 F for 15 to 20 minutes. It usually is necessary to stress relieve where more than one stage of fabrication is involved. For example, the part should be stress relieved after brake forming prior to stretching and also between room temperature hydropress forming stages.

WELDING

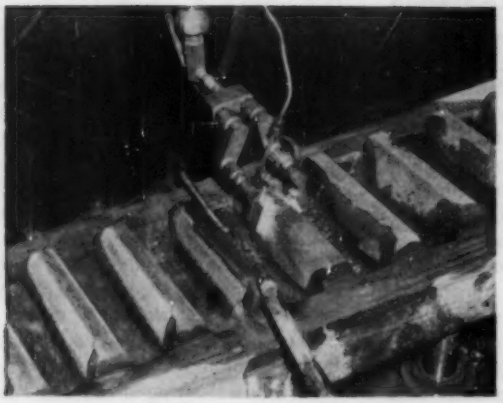
Satisfactory methods for welding titanium include inert-gas shielded arc welding, spot, seam, and flash welding. These methods include provision for shielding the molten weld metals and adjacent heated zones from active gases that would contaminate the metal.

Two major processes for arc welding are the nonconsumable electrode (tungsten arc) and the consumable electrode (titanium or titanium alloy wire) methods. Both methods are adaptable to manual or automatic type arc welding equipment.

Spot, seam, and flash welding procedures for titanium are similar to those used on other metals. Special shielding is usually not required because of the short welding times and proximity of the surfaces being joined. Welding current and time have the greatest effect on the quality of spot and seam welds and should be closely watched for best results.

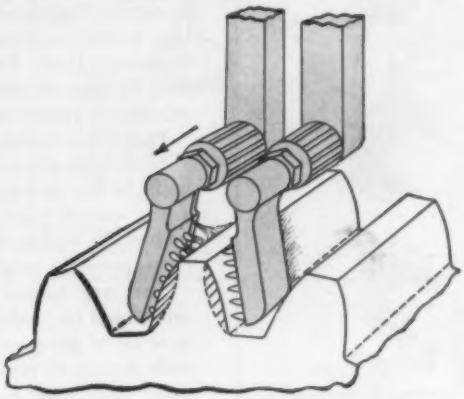
REFERENCE:

Titanium: Metal With An Exciting Future by J. M. Wentzell, Technical Service Director, Atlas Titanium Ltd, Welland, Ont, Canada. Published in Design Engineering, Oct '59, p 52.



From: American Machinist Metalworking Manufacturing

FLAME HARDENING A GEAR RACK requires hardening the flats along both edges and the individual gear teeth. Rack is about 10 ft long, has 26 teeth, is used in a rolling mill. Flats were heated with standard flat burners; the teeth with standard gear-tooth burners like those at right.



matching the burner to the job is key to better . . .

. . . FLAME HARDENING

Burner styles, methods and applications for: Shafts, machine ways, internal bores and splines, gears, racks, journals, cams, and sprockets.

B. G. WARD, JR.
Heat Treatment Engineer
National Cylinder Gas
Div. of Chemetron Corp.

Recent advances in gas-mixing equipment, operating controls, and burner design, are helping flame hardening to find new and varied applications.

Production quantity should be one of the first considerations when choosing between induction and flame hardening, if both processes can provide the desired hardening pattern. Other things being equal, flame hardening is more suitable for short runs, induction hardening for longer runs.

Among other factors to be weighed are: Original equipment cost is lower for flame hardening than for induction hardening for a particular arrangement; flame hardening provides greater freedom in treating large areas with deep, often varying, penetration; burners are easily located for hardening complex contours; recent advances in automatic flame hardening controls now provide a high degree of reliability and uniformity adequate for any hardening job.

BURNER STYLES

Assuming that flame hardening has been selected for a job, the heat treating specialist must then determine the best type of burner and the best flame-hardening method. Poor selection here can adversely affect both the quality and cost of the product.

There are four basic types of burners—all with their inherent advantages and disadvantages:

• **Welding tip**—Standard torch head delivers heat to a relatively small circular area. This is the least expensive burner, but it is practical only for hardening small parts or limited areas of larger parts.

• **Flat**—This type of burner allows full freedom in specifying dimensions of the flame face (provided fuel supply is adequate). The flat burner is relatively inexpensive if it is possible to make a selection from among the standard flame-face dimensions and heating capacities available.

• **Contoured**—The flame face of a contoured burner can be shaped to match the workpiece contour. These burners must be custom-built, but may be more economical to operate than a combination of less expensive flat burners because of reductions in hardening time and fuel consumption.

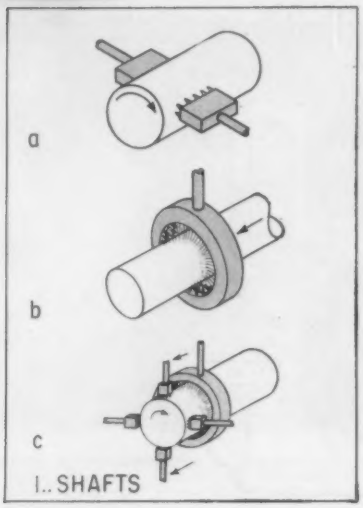
• **Ring**—Ring burners can be built to any desired diameter. They also come in standard sizes, though a special diameter must usually be specified to match a non-standard shaft size.

FLAME-HARDENING METHODS

There are four basic flame-hardening methods:

Stationary—Both the burner and the workpiece are stationary during hardening. Total hardening area may be increased by indexing the piece or burner after each heat-and-quench.

Stationary spinning—Burners are stationary; piece rotates or spins under



the flame to extend the hardening area. Stationary spinning may also be used simply to insure more even heat distribution, as in hardening a shaft with a ring burner.

Progressive – Piece is stationary; burner moves at a constant rate across the surface to be hardened. Quenching is also progressive, either separately or following on the burner head. It may be advantageous, too, to combine a stationary burner with a progressive part.

Progressive spinning – Both the burner and the piece move. The piece spins under the flame as the burner progresses in an axial direction.

APPLICATIONS

The bulk of flame hardening work in industry can be broken into eight.

Shafts

The best burner for hardening a shaft often depends upon shaft diameter. Very small shafts, less than 1 in. dia, can be hardened by a welding tip, by either the progressive spinning or stationary spinning method. Small shafts can be hardened by one or two standard flat burners (1a) with progressive spinning or, if only a narrow band need be hardened, with stationary spinning. If the burners have quenching nozzles, the shaft should be hardened by upward progression in a vertical position so as to lose the quench water.

Burner travel rate along the shaft should be from 2 to 12 ipm, depending upon heat capacity of the gas mixture and burners, and the penetration desired.

The combination ring burner and quench (1b) can heat shafts of any diameter. Progressive hardening with ring burners involves motion of both burner and shaft. The shaft should always be spun to insure uniform hardness and to minimize distortion.

Progressive spinning is usually applied to large-diameter shafts through multiple flat or segment burners and a ring quench (1c). The number of burners for a given shaft diameter depends upon the progressive speed.

The ring burner is usually most economical for shafts of any size, both in terms of gas consumption and also, with respect to multiple burners, because only one torch handle, gas mixer, and set of controls are needed.

Machine ways

Flame hardening of flat and contoured-bed ways is always done progressively because of the size and weight of the work, but burner arrangement may vary a good deal. Flat ways (2a), such as those on boring and drilling machines, are usually hardened with separate burners provided the production run is not too large. Ways may be produced by a company in several widths but with uniform depth. In such cases, one set of side burners may be used for a number of way sizes. A separate top burner, however, should be specified for each way width to insure uniform heat.

Lathe-bed ways can be flame hardened with (a) one burner in three passes, if the widths of the sloping sides and flat are the same; (b) three separate burners in one pass (b); (c) two burners on the "V" in one pass and another burner on the flat in a second pass; or (d) a special contoured burner with three separate flame faces in a single head and with a common gas mixer, supplied through a single gas control system.

The most practical method, both in initial and operating costs, is three standard burners in one pass. If quantity is sufficient to offset the higher initial cost, however, a specially contoured burner is simpler and usually provides more uniform hardening.

Internal bores and splines

Small bores can be flame-hardened with a circular burner and quench (3a). Although simple progressive treatment is possible for deep bores, a more uniform heat distribution is achieved by spinning the piece at the same time. The motion of the circular burner should be upward, so that quench water falls down through the bore. Stationary spinning is sufficient if the bore is shallow enough to permit a practical burner width, and if quenching can be done afterwards. Circular burners become impractical to make in sizes below ¾ in. dia.

Large bores may be hardened by stationary spinning with one or more flat burners. If the ring or bore is shallow enough, it is rotated until hardening temperature is reached, then the burners are removed and the quench heads are inserted.

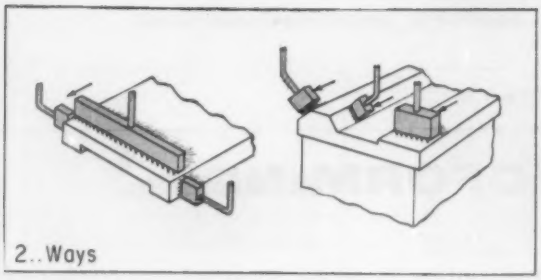
A single flat burner may be used for progressive hardening of extremely large bores if the spinning method cannot develop proper hardening temperature and quenching around the entire bore. To prevent tempering an already hardened area, install an auxiliary quench just ahead of the burner (3b). Only one burner should be used in this setup. The burner and primary quench should be located at the top of the bore, or the bore ring should be hardened in the horizontal position.

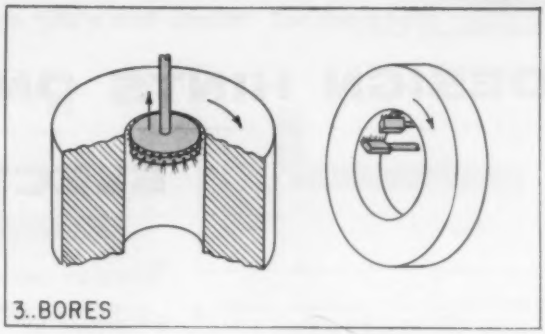
Spline hardening is quite similar to internal bore hardening. Stationary spinning is acceptable for narrow splines, up to about 2 in. wide. Progressive spinning produces less distortion and is useful on splines from 2 to 8 in. wide. Both methods, of course, produce the full-tooth hardening pattern shown in Fig. 4a. If only the spline faces are to be hardened, progressive hardening with two burners traveling along each tooth cavity should be specified. This is similar to the gear hardening operation in Fig. 4b.

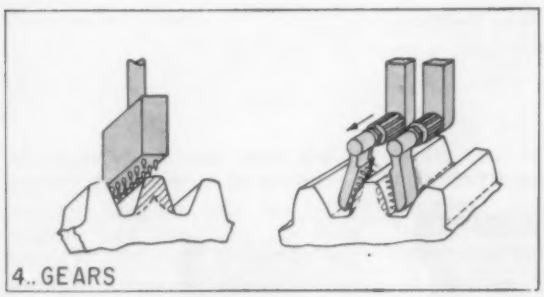
Gears

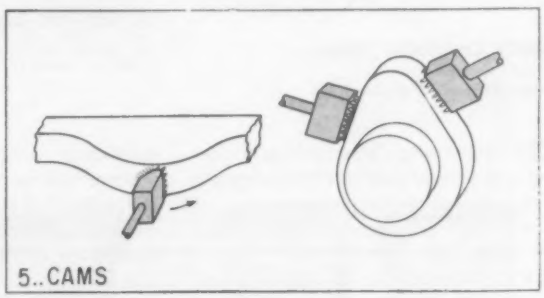
Gears can be hardened in three ways. If the gear teeth are less than ½ in. wide, a twin welding tip can heat each side of a tooth simultaneously. The gear is then indexed, and the heated tooth is quenched as the next tooth is heated. Multi-flame tips may be used for teeth over ½ in. wide.

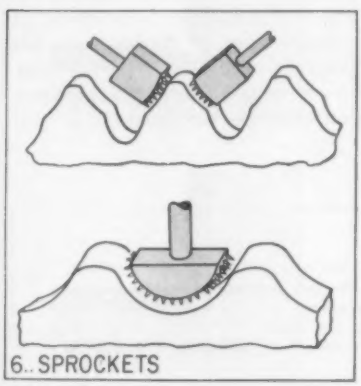
Gears may also be hardened by the spinning technique, using standard flat burners. The gear is spun under











the burners until the teeth have reached hardening temperature, then the gear is dropped into the quench or indexed to a spray quench. Spinning provides the hardening pattern shown in Fig. 4a, and can be used for gears up to 24 in. in diameter and 4 in. wide.

Progressive hardening is accomplished by two flat or contoured burners moving simultaneously across the working faces of each gear tooth (4b), progressively heating and quenching the tooth. Although slower than stationary spinning, progressive hardening is usually specified (a) when only the working faces of the gear are to be hardened usually in heavy gears subject to high shear stresses; (b) when gears are quite large, over 24 in. x 4 in.; and (c) when gears are special designs for precision machines.

Racks

Because of the length of the teeth, racks are almost always hardened progressively. Twin tips like those in sketch are commonly used.

Journals

Journals are usually hardened by spinning, in much the same way as shafts. Heating is followed by a quench. Progressive hardening, in which the burner and quench travel around the journal shaft, is possible, but soft spots might develop at the end of the cycle.

Cams and Camshafts

Most linear cams are hardened progressively in a horizontal position with a flat burner and quench (5a). The contour of the cam can be followed by adapting a duplicate cam, by placing a follower guide in front of or behind the burner, or by positioning the burner by hand.

When only limited areas of the cam need be hardened, the stationary method can be used, as in Fig. 5b, where we show two separate areas being hardened. Greater hardening area and more uniform heat distribution can be obtained by oscillating the cam itself, not more than 15°, under the burners.

Progressive hardening is often specified when the entire cam profile is to be hardened and the piece is being made in reasonable quantities. Cam rollers move the burner and quench in and out as the cam rotates. Progressive cam hardening is best carried out in a horizontal position.

Sprockets

Two flat or slightly contoured burners may be used in stationary hardening to heat simultaneously both sides of each sprocket tooth (6a). After heating, the burners automatically withdraw, and the sprocket is indexed for quenching. Sprockets (and gears) may sometimes be stacked to allow progressive hardening along each line of teeth. This can save considerable time, and improve heat distribution. In Fig. 6a only the tooth tip is hardened. The application determines which of the hardening patterns is required.

REFERENCE:

The Key to Better Flame Hardening: Match the Burner to the Jobs by B. G. Ward, Jr, Heat Treatment Engineer, National Cylinder Gas, Div. of Chemetron Corp, 840 N Michigan Ave, Chicago, Ill. Published in American Machinist, Nov 16 '59, p. 135.

From: Company booklet

DESIGN HINTS ON . . .

ELECTROFORMING

When to use electroforming, types of mandrels, examples of good and bad practices, deposit rates, and distribution curves for angles and holes.

BRUCE CHANDLER JONES
Chief Engineer
Allied Research & Engineering

Electroforming, the process of building a structural part of electro-deposition, consists of three steps:

- Prepare a mandrel of appropriate shape and finish,
- Electro-plate it to the desired thickness,
- Remove the mandrel. (In some instances, the mandrel is not removed.)

Any contour or surface detail given to the mandrel, whether by casting, machining, scribing, or any other process, will be reproduced faithfully in the finished electroform. The process lends itself, therefore, to the reproduction of shapes and surface details which would be difficult or impossible to duplicate by other means. It brings new freedom from certain limitations of conventional machine operations, to designer, engineer and manufacturer alike. There is little or no waste of materials.

Any metal that can be electro-deposited can be electroformed. Copper, nickel and silver are most common, with iron, gold, brass, lead, rhodium and chromium also used. Precious metals often are laminated to plastic or ceramic bases, as in the case of slip rings or commutators. The advent of hydrogen-firing of copper parts has brought a need for copper that contains no oxygen-bearing contaminants; electroforming can produce oxygen-

Some current uses for electroforming

Radar and microwave components:
Waveguides, feed horns,
Power dividers, filters,
Antennas and components
Wind tunnel nozzles and throats
Missile nose cones
Liquid rocket thrust chambers
Radome molds
Venturi nozzles
Pitot tubes
Aircraft ducting
Commutators and slip rings
Honeycomb sandwich
Surface finish gauges
Precision thin-walled tubing
Heat exchanger tubes
Bi-metallic tubing
Reflectors
Tire molds
Musical instruments bells
Phonograph record masters
Printing electrotypes
Caps for fountain pens, ball point pens, pencils
Molds for metal, plastic, ceramic forming
Conducting surfaces on non-conducting materials
Build-up of worn shafts and other parts
Joining of materials at room temperature

When to Use Electroforming

Electroforming should be used when it is less expensive than other methods, when it produces a better product, when it is the only practical method of fabrication. These are the advantages electroforming offers:

Internal surfaces can be contoured to almost any shape.

Where the inspection of internal surfaces is difficult or impossible it is easy to inspect the male mandrel.

There is no size limit, either small or large, except the size of the electroforming tank.

Any surface detail, even as fine as one-millionth of an inch, can be reproduced faithfully.

There is no minimum or maximum wall thickness—walls as thick as two inches have been produced. Further, wall thickness can be duplicated consistently, from part to part.

Components such as pins, plates, wires can be "grown in" and can be of any material which can be plated: similar or dissimilar metals, plastics, ceramics, cermets.

One-piece construction is possible even with complex shapes.

Tolerances as close as 0.0005 in. can be maintained throughout the production run, while surface finish as fine as 2 microinches can be maintained.

Metallurgical properties can be controlled accurately, which helps produce thin-rolled parts that have relatively high strength.

Hardness and strength can be controlled over a wide range.

There is no limit to the length of production runs—short for experimental production, or long for full production.

There is no heat distortion since no heat is applied at any stage of the process.

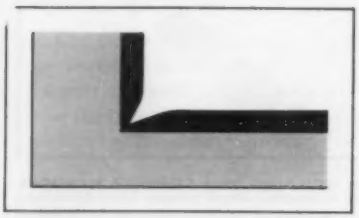
Dissimilar materials can be joined—without applying heat—including any material that can be electro-plated, e.g. metals, plastics, ceramics, cermets.

A minimum of machining is required after electroforming, because surface details are accurately reproduced.

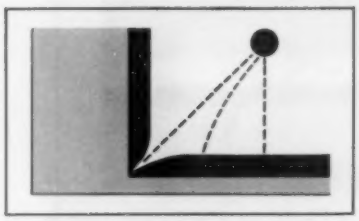
There is little waste of materials, because the deposition of metal can be controlled accurately.

Physical properties can be varied, such as ultimate tensile strength, ductility, yield strength.

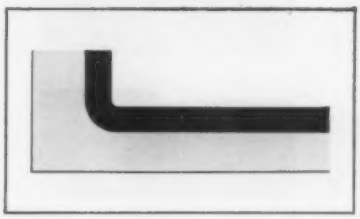
Good electroforming practices—some "do's and don'ts" for designers



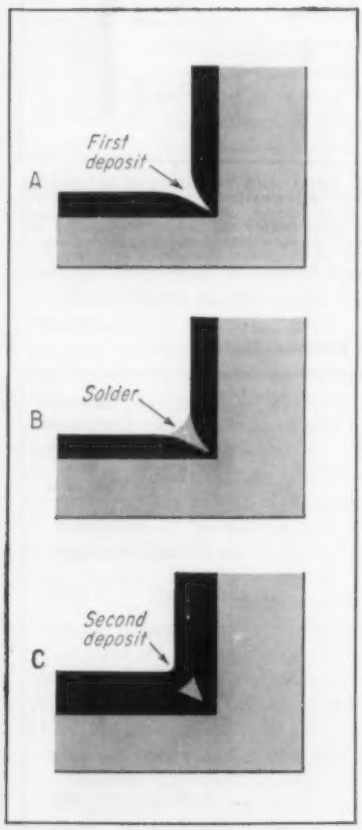
1. DO NOT PLATE INTO SHARP CORNERS (see "Plating into a hole"). Plating into a sharp corner will result in a very light deposit of metal. Silver, however, is almost entirely free of this effect.



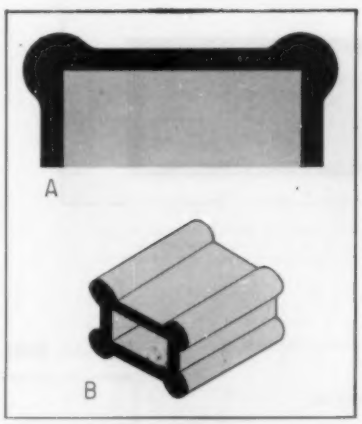
2. WHY A SHARP CORNER CAUSES A THIN DEPOSIT OF METAL. The lines of current-flow arrange themselves like iron filings above a magnet—into straight lines from anode to cathode. Since the distance to one side or the other is less than to the corner, the current flows to the sides, so that only a light deposit of metal is built up in the corner.



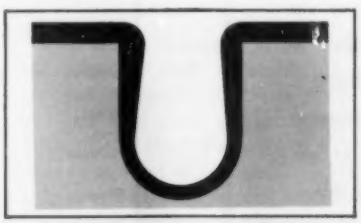
3. ROUND CORNERS WHEN POSSIBLE. By rounding the corner, an even deposit of metal is obtained. Compare this with the sharp corner in Fig. 1.



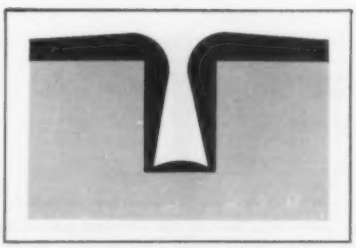
4. USING SOLDER TO AUGMENT A CORNER. Where the corner must be sharp, it may sometimes be possible to build it up with solder, after an initial deposit of metal. The solder (B) is added to the sharp corner, and given a radius. Then electroforming is continued, and an even deposit of metal is obtained on top of the original deposit and over the solder. This results in an appreciably stronger finished part than that shown in Fig. 1. Before designing a part in this way, consider operating conditions such as temperature, which may limit its usefulness.



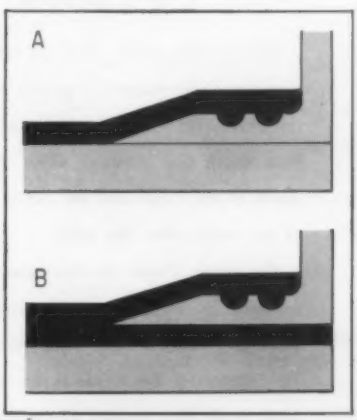
5. METAL BUILDUP AT OUTSIDE CORNERS. The thickness of the metal deposit at a given point is proportional to the electric current density at that point. The current pattern in an electroforming bath is analogous to the magnetic flux pattern about a magnet—more concentrated at outside corners. Therefore, more metal is deposited on the outside corners of a mandrel, resulting in actual reinforcement of electroformed hollow tubes (B) with rectangular or square cross sections.



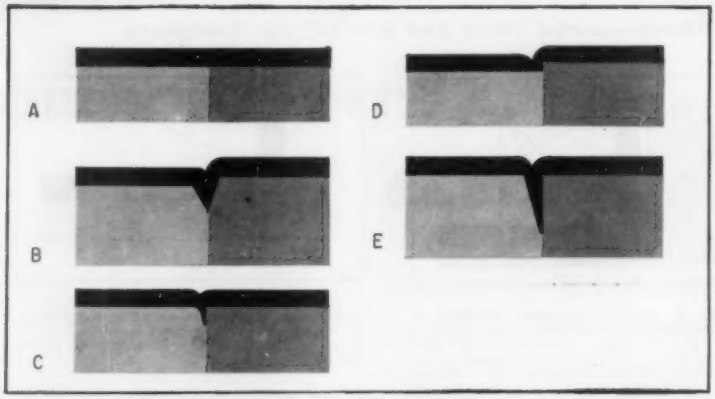
7. THINNER METAL DEPOSIT ON THE BOTTOM OF A HOLE. A hole in the mandrel will, of course, result in a "button" on the internal surface of the electroform. In a manner similar to the way in which only a thin deposit builds up in a sharp corner or a groove, there will be a thinner deposit at the bottom of the hole.



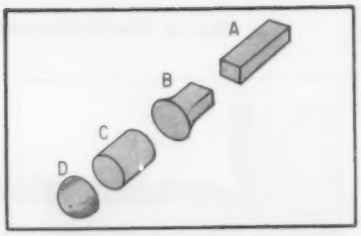
6. AVOID DEEP GROVES. Deep grooves act just as do sharp corners—they tend to prevent an even deposit of metal at the bottom of the groove, and also tend to cause a buildup of metal at the top corner. Whenever possible, round the corners and taper the walls.



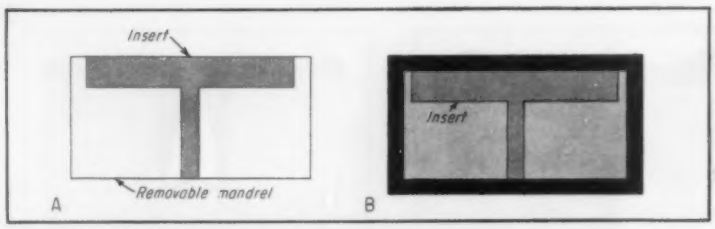
8. ELECTROFORMING A FLANGE IN PLACE. Flanges may be built right into an electroformed part. The flange is press-fit into place (A) on the mandrel, before being placed in the electroforming tank. An initial deposit of metal (B) is electroformed, then the flange fitted or pressed onto the electroform. The assembly is then returned to the electroforming tank, and electroforming is completed. The flange may be masked, wherever on its surface no deposit of metal is desired. Note the locking grooves, to help hold the flange in place.



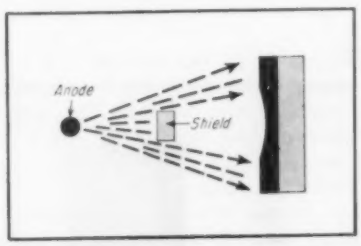
9. TWO-PIECE MANDREL SHOULD HAVE SMOOTH JOINTS. Where the mandrel is made up of two or more pieces, make the joints as smooth as possible (A) to obtain a smooth electroform. Ridging and lack of smooth surface may result (B) where the two parts of a mandrel do not have smooth joints. Discontinuities that may result when a mandrel is made up of more than one piece are shown in G, D and E.



10. BUILDING UP A COMPLEX MANDREL out of several simple pieces. Illustrated here is a method of building a complex mandrel out of several simple shapes—a square rod A, a square-to-round transition B, a round rod C, and a machined cap D. Each part of the mandrel may, if desired, be made of a different material, either for easy removal or to be left in place as part of the finished piece.



11. MANDREL MADE OF DISSIMILAR MATERIALS, some of which remain as part of the finished electroform. The mandrel (A) is made up of dissimilar materials. The expendable portion of the mandrel can be removed (B) leaving the rest as a built-in part of the finished electroform



12. SHIELDING TO ACHIEVE SELECTIVE ELECTROFORMING. The shield deflects the flow of current, effecting a thinner deposit of metal behind the shield. By leaving the shield in the electroforming tank for only a part of the time, the depth of plating at selected points can be controlled accurately.

Plating into a Hole, an Angle, or a Groove

The following charts show the ratio of plating thickness at the bottom of a hole and an angle (or groove) to the plating thickness at the top. Hole depth and diameter affect the ratio; the depth of the angle and the radius at the apex of the angle affect the ratio.

The values shown are approximate, they are suitable for design purposes only while the value of *T* remains small compared to *R* and *L*. The location of the anode in the electroforming tank, and the precise configuration of the electroform itself may affect the values shown. The data do not take into consideration the formation of electroform beads on external corners.

Deposit Rate for Various Metals

Metal	Pounds deposited per amp-hr	Amp-hrs to deposit 0.001-in. thick, per sq in.
Cadmium	0.00462	0.0676
Chromium	0.00071	0.3597
Copper (ous)	0.00523	0.0617
Copper (ic)	0.00261	0.1236
Iron (ous)	0.00230	0.1243
Lead	0.00852	0.0479
Nickel	0.00241	0.1319
Platinum	0.00401	0.1930
Silver	0.00887	0.0430
Tin (ous)	0.00488	0.0542
Tin (ic)	0.00244	0.1083
Zinc	0.00269	0.0993

free high conductivity (OFHC) copper in its purest form.

MANDRELS

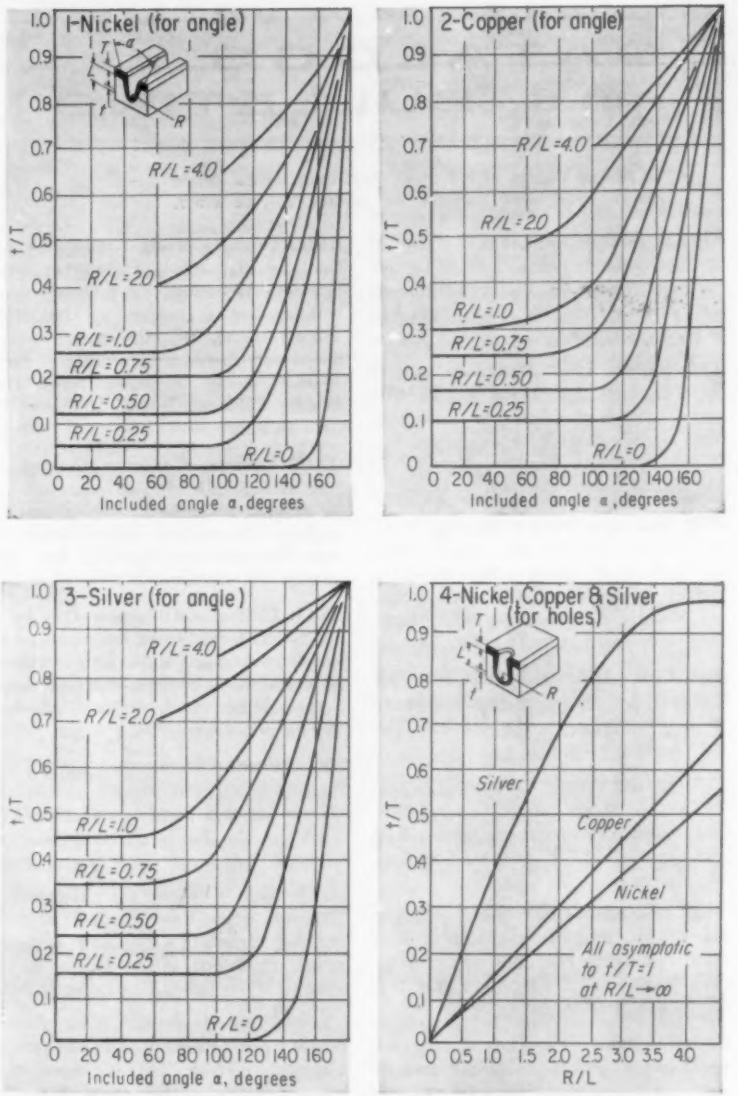
The electroforming process—making the mandrel, then plating it—covers a number of well known and widely used manufacturing procedures. These include metalworking processes such as casting, milling, screw-machining, drilling and tapping, forging, welding and brazing; the molding and machining of synthetics and ceramics; and, of course, electro-plating.

Familiarity with these well known processes notwithstanding, electroforming presents a challenge to the designer and the production engineer —much more so, perhaps, than is generally recognized. Good electroforming practice calls not only for know-how and experience in each of the separate procedures which may be employed, but also in the combining of the mechanical process of making the mandrel, the electro-chemical process of plating it, and whatever associated processes may have preceded or will follow.

The shape of the mandrel is, of course, the reverse of the finished electroform. Every contour, every surface detail is reflected exactly in the electroformed part; a mirror finish on the mandrel means a mirror finish on the electroform; a scratch on the mandrel means a ridge on the electroform.

Mandrels can be made of any material, metallic or non-metallic, conductive or non-conductive, which can be electro-plated, so long as the surface is impervious to the plating solution. Stainless steel, other steels, aluminum, brass, nickel, zinc, bismuth or tin alloys, wax, wood, plastic, rubbed, ceramics and cermets, synthetic materials such as Teflon, Nylon, Kel-F, laminates and foams and other plastics are among those commonly used. There are several ways of putting a conductive coating on a non-conductive mandrel e.g. dusting with powdered graphite, dipping in colloidal graphite, "electroless" plating.

Permanent mandrels can be pulled out of the electroform, and reused. To prevent adhesion and permit removal, give the surface an oxide coating. Conversely, if adhesion is desired, clean the surface chemically and physically. For close-tolerances make mandrels of stainless steel.



NORMAL ELECTROFORM DISTRIBUTION for nickel, copper and silver in angles, grooves and holes.

Expendable mandrels, made of soluble materials such as aluminum or zinc, or of fusible materials such as wax, are used when the internal contours of the electroform make it possible to pull out the mandrel. Expendable mandrels are also used where the cost of a permanent mandrel would be appreciably higher, as in experimental or other short-run production. For close tolerance parts, expendable mandrels are usually made of aluminum.

In many instances, the mandrel, or a portion of it, is not removed. Inserts, pins, wires may be left in place. A plastic or ceramic base may be electro-plated in a specified pattern, as is done with a slip ring or commutator.

REFERENCE:

Current Uses for Electroforming by Bruce Chandler Jones, Chief Engineer, Allied Research & Engineering. Published by Allied Research & Engineering, Div of Allied Record Manufacturing Co, Los Angeles, California

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(D-1) **Screw Conveyor Drives**—Catalog, 20 pp. Gear reducers handle ½ to 30 hp. Attaching trough ends and motor mounts also shown. The Falk Corp, Box 492, Milwaukee, Wisc.

(D-2) **Impulse Load Motors**—Bulletin, 4 pp. Describes high inertia motors with built-in clutch and brake to accomplish rapid starts and stops of production machinery. Ferguson Machine Corp, 7818 Maplewood Industrial Court, St Louis.

(D-3) **Automatic Work Positioning**—Catalog, 38 pp. Describes index tables, index table drives with several motion schedules, transfer machines and accessories. Ferguson Machine Corp of Ind, 7818 Maplewood Industrial Court, St Louis.

(D-4) **Cold Heading**—Bulletin, 8 pp. Discusses the process, its possibilities and its limitations. John Hassall, Inc, Box 2233H, Westbury, NY.

(D-5) **Jig and Fixture Components**—Catalog, 80 pp. Shows handles, clamps, buttons, bushings, many others. Jergens Tool Specialty Co, 712 E 163 St, Cleveland 10.

(D-6) **Template Drill Bushings**—Bulletin, 16 pp. Bushings are used in thin metal templates. For drills up to ¾ in. Penn Engineering & Mfg Corp, Box 311, Doylestown, Pa.

(D-7) **Inspection Projectors**—Catalog, 8 pp. Explains projection method used in described comparators, measurers and machine tool projectors. Stocker & Yale, Inc, 44 Green St, Marblehead, Mass.

(D-8) **Inspection Equipment**—Brochure, 6 pp. Explains optical system and comparators and measuring projectors it is used in. Stocker & Yale, Inc, 40 Green St, Marblehead, Mass.

(D-9) **Metal Spinning**—Brochure, 6 pp. Compares spinning and pressing costs, shows steps in process and tolerances and capacities within which company works. C W Torngren Co, Inc, 236 Pearl St, Somerville, Mass.

(D-10) **Laboratory Presses**—Brochure, 4 pp. Describes 3 to 50 ton self-contained hydraulic presses with or without heated platens. Wabash Metal Products Co, 1582 Morris St, Wabash, Ind.

(D-11) **Grooving Tools**—Catalog, 20 pp. Contains illustrations, engineering specifications, dimensions for grooving tools, bottom adaptors, elongated spindles, other special attachments. Also covers cutting ranges and speeds, tool setup and maintenance. Truarc Retaining Rings Div, Waldes Kohinoor, Inc, 47-16 Austel Pl, LI City 1, NY.

(D-12) **Vibrating Conveyors**—Catalog, 16 pp. Mechanically vibrated conveyors can be adapted to perform washing, sorting, aligning de-watering, other functions. Ajax Flexible Coupling Co, Inc, 104 Portage Rd, Westfield, NY.

(D-13) **Drilling and Tapping**—Catalog, 8 pp. Gives drawings and specifications of air powered tapping and drilling machines, air and hydraulic powered drill press feeds. Beckett-Harcum Co, 985 W Locust, Wilmington, Ohio.

(D-14) **Plastic Coloring**—Bulletin, 15 pp. Presents a cost and property comparison of painting and molding in color. Bee Chemical Co, 12933 S Stony Is. Ave, Chicago 33.

(D-15) **Mist Coolant for Machining**—Brochure, 6 pp. Unit, which mounts on machine, consists of reservoir and necessary valves, regulators, filters. Hooks up to shop air. Bijur Lubricating Corp, Rochelle Park, NJ.

(D-16) **Spray Painting**—Bulletin, 4 pp. Describes portable and stationary high pressure, airless outfits. Binks Mfg Co, 3114 Carroll Ave, Chicago.

(D-17) **Sprayer-mixer**—Bulletin, 4 pp. Presents proportioner and mixing gun for spraying, pouring or foaming multiple component materials. Binks Mfg Co, 3114 Carroll Ave, Chicago.

(D-18) **Plating Process**—Bulletin, 4 pp. Presents advantages and illustrations of process of nickel and chrome plating on zinc and steel. Brown-Lipe-Chapin Div, General Motors Corp, Town Line Rd, Syracuse, NY.

(D-19) **Internal Grinders**—Catalog, 16 pp. Describes, provides specifications of grinders adapted to toolroom, small lot production and high volume production. Bryant Chucking Grinder Co, Clinton St, Springfield, Vt.

(D-20) **Turrent Drills**—Two brochures, 12 pp. Describes six-spindle, production machines with ½ and ¾ in. hole dia. capacities. Burg Tool Mfg Co, 15001 S Figueroa St, Gardena, Cal.

(D-21) **Radial Turret Drill**—Brochure, 6 pp. Six-spindle machine drills up to ¾ in. diameter holes. Maximum radius of ram swing is 42 in. Burg Tool Mfg. Co, 15001 S Figueroa St, Gardena, Cal.

(D-22) **Automatic Turrent Drills**—Bulletin, 12 pp. Presents six and eight-spindle, hydraulic feed machines for drilling, tapping, boring. Burg Tool Mfg Co, 15001 S Figueroa St, Gardena, Cal.

(D-23) **Programmed Turret Drill**—Bulletin, 8 pp. Shows six and eight-spindle machines with punched tape control system. Burg Tool Mfg Co, 15001 S Figueroa St, Gardena, Cal.

(D-24) **Bench Turret Drill**—Bulletin, 4 pp. Describes six-spindle, twelve total speeds machine for small holes, bench mounting. Burgmaster Corp, 15001 S Figueroa St, Gardena, Cal.

(D-25) **Tool Holders**—Bulletin, 4 pp. Lists sizes of releasing, nonreleasing and quick change types which self center tools for boring, tapping, drilling. Burgmaster Corp, 15001 S Figueroa St, Gardena, Cal.

(D-26) **Grinding Wheels and Abrasives**—Catalog, 74 pp. Gives drawings, sizes and uses of all kinds of wheels, sticks, discs. Includes loose grains and powders. Bonded Abrasives Div, The Carborundum Co, Niagara Falls, NY.

(D-27) **Barrel Finishing**—Catalog, 38 pp. Expalins how process works and how to choose corrects speeds, media, time, other variables. Gives specifications for machines, media shapes and compounds. Electro Minerals Div, The Carborundum Co, Niagara Falls, NY.

(D-28) **Tool Room Grinding**—Brochure, 26 pp. Discusses abrasives and techniques; shows wheels and sticks for surface, cylindrical, tool and other types of grinding. Bonded Abrasives Div, The Carborundum Co, Niagara Falls, NY.

(D-29) **Belt Grinders**—Data sheets, 27 pp. Gives specifications of automatic and manually operated belt sanders, grinder and polishers. Curtis Machine Div, The Carborundum Co, Niagara Falls, NY.

(D-30) **Machine Tools**—Catalog, 72 pp. Gives descriptions, illustrations and specifications for milling, die sinking, broaching, grinding, metal forming, hardening and special machines plus grinding wheels and cutting fluids. The Cincinnati Milling Machine Co, Cincinnati.

(D-31) Rubberized Abrasive—Brochure, 24 pp. Explains how to use rubberized abrasive grinding wheel. Presents case histories. Lists sizes of wheels, sticks, stones, blocks, points. Cratex Mfg Co, 1600 Rollins Rd, Burlingame, Cal.

(D-32) Air Filtering System—Bulletin, 28 pp. Provides performance curves, capacities, other data on industrial dust control equipment. The Day Co, 810 Third Ave NE, Minneapolis 13.

(D-33) Bulk Materials Handling—Bulletin, 12 pp. Gives dimensions and capacities of vertical and horizontal storage tanks, pneumatic conveying system. The Day Co, 810 Third Ave NE, Minneapolis 13.

(D-34) Dust Separator—Bulletin, 12 pp. Provides performance curves and formulas for choosing correct size cyclonic separator. The Day Co, 810 Third Ave NE, Minneapolis 13.

(D-35) Dust Filter—Bulletin, 8 pp. Presents air capacities and dimensions of reverse flow cleaned, continuous, automatic units. The Day Co, 810 Third Ave NE, Minneapolis 13.

(D-36) Pneumatic Conveyo s—Bulletin, 12 pp. Explains operation and sample systems for moving bulk materials. Mixing, drying, cooling can be done at same time. The Day Co, 810 Third Ave NE, Minneapolis 13.

(D-37) Plug Gages—Bulletin, 4 pp. Shows uses of plug gages made in 0.0001 in. steps, and uses of gage balls. Deltronic, 929 Baker St, Costa Mesa, Cal.

(D-38) Hopper Fed Power Screwdrivers—Brochure, 6 pp. Outlines features, advantages, dimensions. Detroit Power Screwdriver Co, 2801 W Fort St, Detroit 16, Mich.

(D-39) Polyethylene Forming—Brochure, 40 pp. Discusses methods of forming and fields of use. Includes table showing range of properties. Eastman Chemical Products, Inc, Kingsport, Tenn.

(D-40) Vacuum Forming Plastics—Brochure, 20 pp. Discusses economic advantages and usefulness of vacuum forming as a technique for producing acetate and butyrate plastic products. Describes and illustrates basic technique and variations. Eastman Chemical Products, Inc, Kingsport, Tenn.

(D-41) Vacuum and Pressure Filters—Catalog, 12 pp. Describes drum, belt, disc and other type continuous filters from laboratory to large industrial sizes. The Eimco Corp, Box 300, Salt Lake City 10, Utah.

(D-42) Belt Filter—Bulletin, 12 pp. Shows operation of continuous belt drum filter and its uses in food, chemical, other industries. The Eimco Corp, Box 300, Salt Lake City 10, Utah.

(D-43) Magnetic Pulleys—Brochure, 6 pp. When used with materials handling conveyor belt, permanent magnetic pulley removes tramp iron contaminants. Eriez Mfg Co, Erie 6, Pa.

(D-44) Magnetic Automation Components—Brochure, 6 pp. Permanent magnet rails and rollers help convey, elevate or control magnetic parts. Eriez Mfg Co, Erie 6, Pa.

(D-45) Vibratory Feeders—Brochure, 6 pp. Furnishes capacities and other specifications for magnetically driven feeders for loose materials. Capacities range from 1 to 10 tons of material per hour. Eriez Mfg Co, Erie 6, Pa.

(D-46) Machine Levellers—Brochure, 4 pp. Provides specifications of levelling jacks and vibration absorbing pads. Enterprise Machine Parts Corp, 2371 Jerome, Detroit 12.

(D-47) Industrial Weighing—Catalog, 75 pp. Describes scales with mechanical and optical indication, automatic net weighing, automatic checkweighing and automatic sacking scales, plus other variations. The Exact Weight Scale Co, 551 E Town St, Columbus, Ohio.

(D-48) Laboratory Mills—Bulletin, 16 pp. Describes 6 by 13 in. roll size mills for plastic and rubber. Also mixers and calenders. Farrel-Birmingham Co, Inc, Ansonia, Conn.

(D-49) Gear Production—Catalog, 20 pp. Describes capabilities and specifications of equipment for cutting, finishing and inspecting gears, worms, threads. Includes special-purpose attachments. The Fellows Gear Shaper Co, 78 River St, Springfield, Vt.

(D-50) Pressure Filter—Bulletin, 8 pp. Describes automatic, continuous flow, diatomite filter for aluminum oil recovery. Gale Separator Co, Div of Infilco, Inc, 901 S Campbell Ave, Tucson, Arizona.

(D-51) Annealing Furnace—Bulletin, 4 pp. Electric furnace continuously anneals stainless steel strip. Table gives production ratings for different width strip. Industrial Heating Dept, G E Co, Shelbyville, Ind.

(D-52) Neutralene Gas Producer—Bulletin, 4 pp. Equipment produces a neutral atmosphere to prevent oxidation and decarburizing during heat treatment. Plant dimensions and ratings and gas composition are given. Industrial Heating Dept, G E Co, Shelbyville, Ind.

(D-53) Malleable Iron Annealing Furnace—Bulletin, 4 pp. Electric furnaces handle up to 8 tons per batch. Dimensions and operating cycle curves are given. Industrial Heating Dept, G E Co, Shelbyville, Ind.

(D-54) Exalene Gas Producer—Bulletin, 4 pp. Equipment produces atmosphere for bright annealing, normalizing, hardening, brazing and sintering of low-carbon steels, brass and copper. Industrial Heating Dept, G E Co, Shelbyville, Ind.

(D-55) Annealing and Stress Relieving Furnace—Bulletin, 4 pp. Electric furnace handles batches up to 20 tons. Hearth is on elevator. Industrial Heating Dept, G E Co, Shelbyville, Ind.

(D-56) Plasma Jet System—Data folder, 11 pp. Describes equipment for flame spraying and attaining extremely high temperatures. Plasmadyne Corp, Div of Giannini Scientific Corp, 3839 S Main St, Santa Ana, Cal.

(D-57) Threading Lathe—Catalog, 8 pp. Describes semi-automatic, single point type which can do multistart, tapered, other special work. Gisholt Machine Co, 1245 E Washington Ave, Madison, Wisc.

(D-58) Automatic Lathes—Catalog, 28 pp. Provides floor plan, specifications, notes on attachments, automation of a design for high production. Gisholt Machine Co, 1245 E Washington Ave, Madison, Wisc.

(D-59) Profiler—Catalog, 12 pp. Describes attachment that positions tool slide by following template. For automatic and turret lathes. Gisholt Machine Co, 1245 E Washington Ave, Madison, Wisc.

(D-60) Automatic Turret Lathes—Catalog, 24 pp. Shows floor plan, construction, attachments of machine which can in great part be set up electrically. Gisholt Machine Co, 1245 E Washington Ave, Madison, Wisc.

(D-61) Automatic Lathes—Catalog, 24 pp. Describes lathe having large horizontal table for tool carrying slides. Tooling is added in building block manner. Gisholt Machine Co, 1245 E Washington Ave, Madison, Wisc.

(D-62) Saddle Turret Lathes—Five brochures, 40 pp. Describes models with swings up to 40 in. Machines are designed to give high production rates. Gisholt Machine Co, 1245 E Washington Ave, Madison, Wisc.

(D-63) Ram Turret Lathes—Catalog, 20 pp. Shows construction, accessories, tooling, floor plans of models having up to 21¾ in. swings. Gisholt Machine Co, 1245 E Washington Ave, Madison, Wisc.

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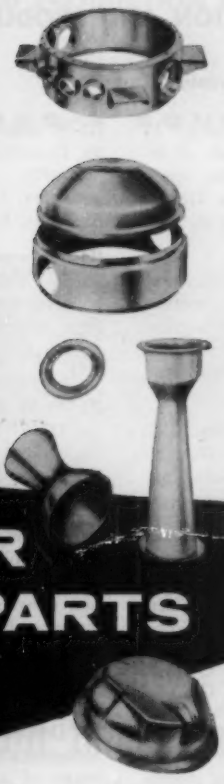

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(D-64) **Balancing Machines**—Catalog, 36 pp. Discusses imbalance, methods of detecting, locating, correcting. Gives specifications, capabilities of balancers. Gisholt Machine Co, 1245 E Washington Ave, Madison, Wisc.

(D-65) **Stone Metal Finishing**—Catalog, 48 pp. Shows how finishing method works and its advantages. Presents specifications, floor plans, uses of machines. Gisholt Machine Co, 1245 E Washington Ave, Madison, Wisc.

(D-66) **Tracer Controlled Millers**—Two brochures, 12 pp. Describes specifications and operation of automatic tracing machines for two and three dimensional work. George Gorton Machine Co, 1312 Racine St, Racine, Wisc.

(D-67) **Drilling and Tapping**—Brochure, 4 pp. Describes automatic, self-contained, hydraulically controlled units. The Govro-Nelson Co, 1931 Antoinette St, Detroit 8.

(D-68) **Zinc Die Castings**—Catalog, 8 pp. Gives zinc alloy properties, comparison of die casting with other methods and design guides for designing for the process. Gries Reproducer Corp, 159 Beechwood Ave, New Rochelle, NY.

(D-69) **Metal Expanders**—Bulletin, 8 pp. Explains how expanders work and how to choose a machine and die setup for a job. Machines are hydraulically or mechanically powered. Grotnes Machine Works, Inc, 5454 N Wolcott Ave, Chicago 40.

(D-70) **Metalworking Machines**—Brochure, 8 pp. Describes metalworking methods and machines—shrinkers, expanders, coilers, roll formers, weld rollers and trimmers and seamers. Grotnes Machine Works, Inc, 5454 N Wolcott Ave, Chicago 40.

(D-71) **Ultrasonic Equipment**—Eleven bulletins, 27 pp. Presents capabilities and specifications of cleaners, foil welders, soldering irons, drills. Gulton Industries, Inc, Vibro-Ceramics Div, 212 Durham Ave, Metuchen, NJ.

(D-72) **Vacuum Equipment**—Data sheets, 8 pp. Describes pressure gages, valves and oil diffusion pumps. High Vacuum Equipment Corp, Subs of Robinson Technical Products, Inc, 2 Churchill Rd, Hingham, Mass.

(D-73) **Electron Beam Welder**—Brochure, 4 pp. Describes vacuum welder for noncontaminating welds in refractory and reactive metals. High Vacuum Equipment Corp, Subs of Robinson Technical Products, Inc, 2 Churchill Rd, Hingham, Mass.

(D-74) **Injection .Molding**—Brochure, 4 pp. Describes hand operated machine for producing research and development quantities. Hinchman Mfg Co, 259 First Ave East, Roselle, NJ.

(D-75) **Investment Castings**—Brochure, 16 pp. Outlines manufacturing process, including ceramic shell technique. Advantages discussed; company capabilities shown. Hitchiner Mfg Co, Inc, Milford, NH.

(D-76) **Marking Equipment**—Brochure, 8 pp. Describes machines for marking, dating, coding and imprinting containers, wrappings. Industrial Marking Equipment Co, Inc, 655 Berriman St, Brooklyn 8, NY.

(D-77) **Drill Heads**—Bulletin, 4 pp. Provides specifications and dimensions of a unit designed for production runs of soft materials. Feed is by air cylinder. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

(D-78) **Rotary Index Tables**—Bulletin, 12 pp. Describes 13 and 26 in. tables which automatically index by air cylinder. Full range of controls for close tolerances. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

(D-79) **Drilling and Tapping Units**—Bulletin, 8 pp. Presents air powered, electrically controlled units with strokes to 3 in. Drilling and tapping units accept a range of drill sizes from no. 80 to ⅞ in. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

(D-80) **Rotary Feed Tables**—Bulletin, 16 pp. Shows 10 and 22 in. tables with air positioning, electrical control. Made for high production rates. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

(D-81) **Drill Press Feeds**—Bulletin, 16 pp. Provides dimensions and operating data for air powered, electrically controlled package for automatic or semiautomatic operation. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

(D-82) **Drilling Units**—Bulletin, 8 pp. Describes heavy-duty, self-contained unit with air powered feed, motor and timing belt head drive, electrical controls designed for high production rates. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

(D-83) **Balancing Machines**—Bulletin, 4 pp. Gives specifications and operation of portable vibration analyzers and balancing machines to handle workpieces to over 1500 lbs. International Research & Development Corp, Box 55, Worthington, Ohio.

(D-84) **Master Gears**—Catalog, 8 pp. Gives tolerances and dimensions of precision, fine pitch spur gears. Invo Spline, Inc, 2357 E Nine Mile Rd, Warren, Mich.

(D-85) **Cutting Tools**—Catalog, 75 pp. Provides illustrations and tables of sizes of taps, drills, end mills, rotary files and other tools. Jarvis Corp, Pease Ave, Middletown, Conn.

(D-86) **Tapping and Drilling**—Catalog, 80 pp. Contains parts lists, sizes, capacities of tapping attachments, multiple drilling and tapping heads and flexible shaft machines. Jarvis Corp, Pease Ave, Middletown, Conn.

(D-87) **Stampings and Deep-drawn Parts**—Bulletin, 4 pp. Presents facilities, capabilities and examples of typical products. Johnson & Hoffman Mfg Corp, 31 E Second St, Mineola, NY.

(D-88) **Punch Press**—Catalog, 4 pp. Describes 5 to 15 ton capacity production presses with safety features designed in to protect operator. Kenco Mfg Co, 5211 Telegraph Rd, Los Angeles 22.

(D-89) **Tumbling**—Catalog, 17 pp. Presents information on wet and dry tumbling equipment and supplies for finishing metals and plastics. H W Kramer Co, Inc, 120-30 Jamaica Ave, Richmond Hill 18, NY.

(D-90) **Saw Blades**—Bulletin, 36 pp. Supplies guides to selection and use of blades for metals and nonmetals. Includes tables of sizes and types. Ladish Co, 5481 S Packard Ave, Cudahy, Wisc.

(D-91) **Induction Heating Equipment**—Catalog, 36 pp. Explains principles and describes equipment for soldering, brazing and heat treating by high frequency heating. Lepel High Frequency Laboratories, Inc, 55 St & 37 Ave, Woodside 77, NY.

(D-92) **Induction Heating**—Bulletin, 12 pp. Two bulletins, 24 pp. Presents articles on brazing, soldering, zone processing by high frequency heating. Lepel High Frequency Laboratories, Inc, 55 St & 37 Ave, Woodside 77, NY.

(D-93) **Powdered Metallurgy**—Three brochures, 24 pp. Contain case histories of applications; tables of data. Metal Powder Industries Federation, 60 E 42 St, NYC 17.

(D-94) **Honing**—Brochure, 8 pp. Explains how process works, gives work capacity curves and brief specifications for production machines. Also shows tools and abrasives. Micromatic Hone Corp, 8100 Schoolcraft Ave, Detroit 38.

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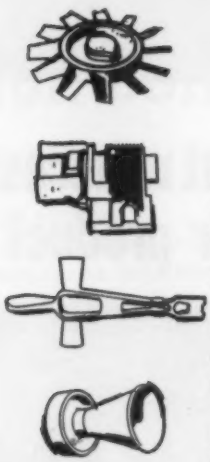

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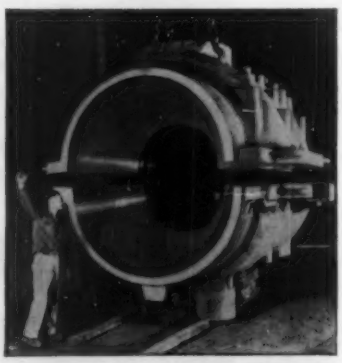

This upper and lower cylinder blade ring for a steam turbine was cast and machined by Blaw-Knox. Weight—55,000 pounds per half.

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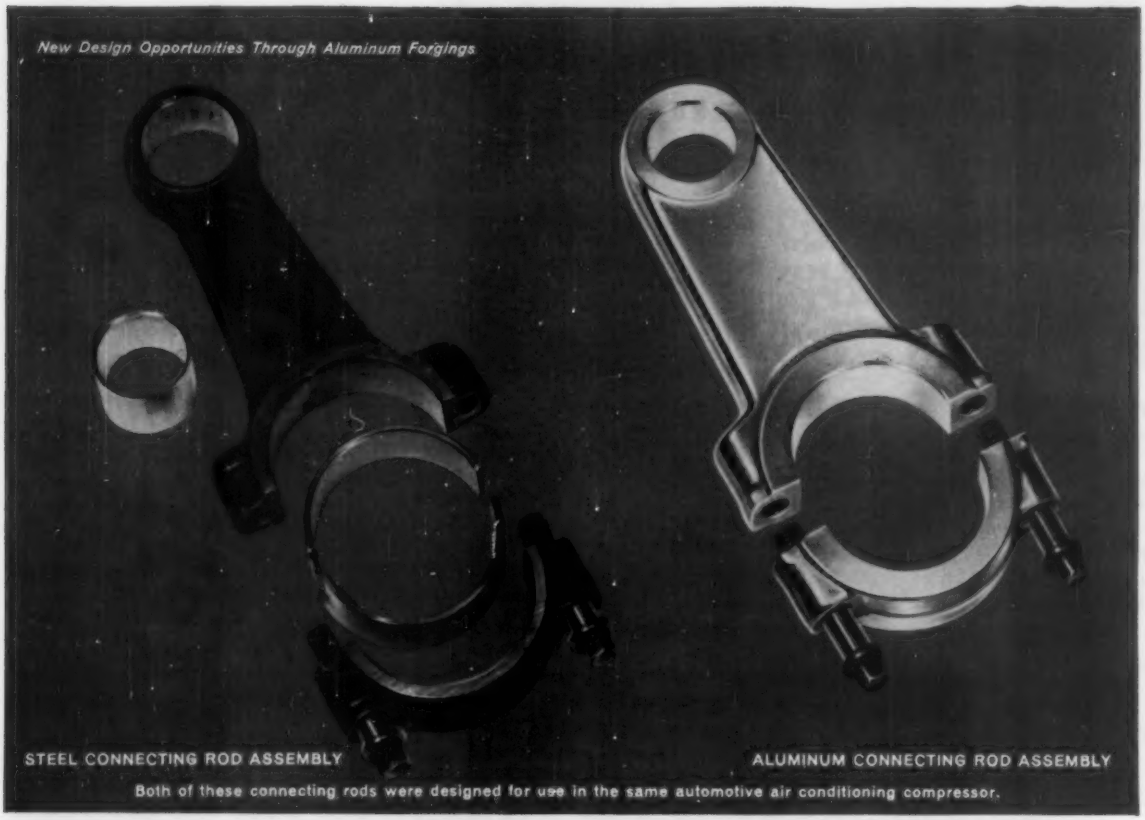

STEEL CONNECTING ROD ASSEMBLY

ALUMINUM CONNECTING ROD ASSEMBLY

Both of these connecting rods were designed for use in the same automotive air conditioning compressor.

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catalogs and bulletins.....continued

(D-95) **Surface Roughness**—Catalog, 12 pp. Presents specifications for equipment and attachments for measuring, indicating, recording roughness. Micrometrical Mfg Co, Box 1067, Ann Arbor, Mich.

(D-96) **Tackle Blocks**—Bulletin, 4 pp. Describes single, double and triple manila and wire rope blocks and gin blocks. Moline Iron Works, Moline, Ill.

(D-97) **Five-chaser Threading Tool**—Bulletin, 7 pp. Describes tool for producing more accurate thread on pieces with flats, keyway slots or drilled holes. The National Acme Co, 170 E 131 St, Cleveland 8.

(D-98) **Clamps and Jig Components**—Catalog, 18 pp. Shows knobs, v-blocks, jig feet, step blocks, set-up sets and others. Gives templates for all items. Northwestern Tools, Inc, 117 Hollier Ave, Dayton, Ohio.

(D-99) **Cleaning and Surface Treating**—Brochure, 28 pp. Describes compounds and methods of tank and ultrasonic cleaning, pickling, paint stripping, others. Oakite Products, Inc, 19 Rector St, NYC 6.

(D-100) **Automatic Filter**—Brochure, 8 pp. Diagrams operation; lists flow rates for different liquids, and dimensions of industrial pressure type. Olson Filtration Engineers, Div of American Laundry Machinery Co, Ross & Section Aves, Cincinnati 12.

(D-101) **Sander**—Bulletin, 8 pp. Describes combination drum and belt sander for plywood and veneered panels. Yates-American Machine Co, 729 Fourth St, Beloit, Wisc.

(D-102) **Plastic Injection Molding**—Catalog, 22 pp. Describes high-speed, automatic machines with 4 to 32 oz capacity. Reed-Prentice Div, Package Machinery Co, 330 W Chestnut St, E Longmeadow, Mass.

(D-103) **Vibrating Finishing Machines**—Bulletin, 4 pp. Machines substitute vibration for tumbling. Amplitude and frequency are controllable. Pangborn Corp, Hagerstown, Md.

(D-104) **Spring Coilers**—Brochure, 8 pp. Illustrates and describes typical applications of hand, power, variable speed and automatic models. Perkins Machine & Gear Co, Circuit Ave, W Springfield, Mass.

(D-105) **Machine Tools and Components**—Bulletin, 35 pp. Illustrates and describes boring machines, motors, arbors, wheel holders, spindles, special machinery. Pope Machinery Corp, 261 River St, Haverhill, Mass.

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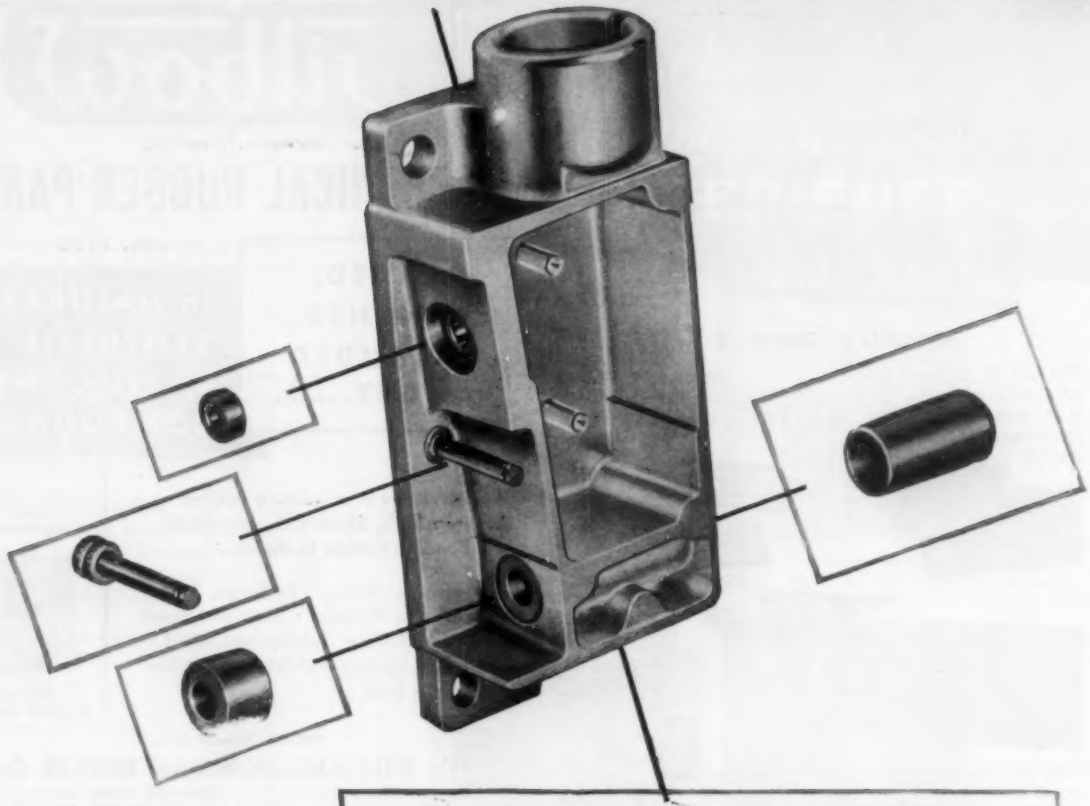

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Catalogs and Bulletins.....continued

(D-106) Machine Tools—Catalog, 36 pp. Describes machine tools, cutting tools, gages, measuring and inspection machines including many automatic and tape-controlled machines. Pratt & Whitney Co, Inc, Charter Oak Blvd, W Hartford, Conn.

(D-107) Thread Rolling Machines—Two bulletins, 16 pp. Provides specifications for two and three cylindrical die machines for work diameters up to 4 in. Reed Rolled Thread Die Co, 791 Main St, Holden, Mass.

(D-108) Thread Rolling Attachment—Bulletin, 8 pp. Describes a two cylindrical die attachment for screw machines or automatic lathes. Reed Rolled Thread Die Co, 791 Main St, Holden, Mass.

(D-109) Thread Rolling Dies—Bulletin, 8 pp. Tells how to select and gives specifications of flat dies for reciprocating machines. Reed Rolled Thread Die Co, 791 Main St, Holden, Mass.

(D-110) Spline Rolling Machine—Bulletin, 8 pp. Describes cylindrical die machine for rolling external involute splines and serrations. Reed Rolled Thread Die Co, 791 Main St, Holden, Mass.

(D-111) Titanium Techniques—Bulletin, 24 pp. Describes techniques for forming and joining titanium and titanium alloy sheet. Includes physical properties and formulae for sheet metal forming. Republic Steel Corp, 1441 Republic Bldg, Cleveland 1.

(D-112) Corrosion Resistant Dip Pipes—Brochure, 4 pp. Teflon lining in these dip pipes, spargers, thermowells and nozzle liners stands up to chemicals and high temperatures. Restoflex Corp, Woodland Rd, Roseland, NJ.

(D-113) Turret Punch Press—Catalog, 14 pp. Gives capacities, specifications of manual and air-hydraulic operated models plus punch and die sets. Rotex Punch Co, Inc, 2350 Alvarado, San Leandro, Cal.

(D-114) Metalworking—Catalog, 12 pp. Gives specifications and capacities for benders, brakes, punch presses, spring winders and other metalworking machinery. O'Neil-Irwin Mfg Co, 425 Eighth Ave, Lake City, Minn.

(D-115) Vertical Mill—Bulletin, 4 pp. Describes small mill with five spindle speeds, tiltable head, 5 by 20 in. table. Rotex Punch Co, Inc, 2350 Alvarado, San Leandro, Cal.

(D-116) Bench Miller—Bulletin, 4 pp. Presents horizontal arbor, 5 by 20 in. power feed table mill for model, small production work. Rotex Punch Co, Inc, 2350 Alvarado, San Leandro, Cal.

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Catalogs and Bulletins.....continued

(D-117) Conveyor Belting—Brochure, 4 pp. Tells about chemical resistance, temperature range, loading and other characteristics of a neoprene impregnated general purpose conveyor belting. The Russell Mfg Co, 400 E Main St, Middletown, Conn.

(D-118) White Cotton Conveyor Belting—Brochure, 4 pp. Weight, strength, temperature range are some data given on this smooth, white belting. The Russell Mfg Co, 400 E Main St, Middletown, Conn.

(D-119) Power Rectifiers—Data folder, 40 pp. Electroplating, battery charging, dc power sources and other equipment use metallic rectifiers. Sel-Rex Corp, 75 River Rd, Nutley 10, NJ.

(D-120) Plating Method—Brochure, 4 pp. Shows process using mobile equipment without immersion tanks. Plating applied with solution saturated stylus. Sifco Metachemical, Inc, 935 E 63 St, Cleveland 3.

(D-121) Screen Separator—Brochure, 22 pp. Sorts wet or dry materials by size. Uses, sizes, capacities given. Vibro-Equipment Div, Southwestern Engineering Co, 4800 Santa Fe Ave, Los Angeles 58.

(D-122) Mill—Brochure, 17 pp. Describes mill which vibrates grinding media to obtain ultrafine end product. Vibro-Equipment Div, Southwestern Engineering Co, 4800 Santa Fe Ave, Los Angeles 58.

(D-123) Vibratory Materials Handling Equipment—Catalog, 68 pp. Provides brief specifications of feeders, shakers, screens, conveyors plus other equipment including lapping machines and weighing machines. Syntron Co, 240 Lexington Ave, Homer City, Pa.

(D-124) Resistance Welders—Brochure, 12 pp. Illustrates and describes 32 multispot and projection machines for automatic operation. Taylor-Winfield Corp, 1052 Mahoning Rd, Warren, Ohio.

(D-125) Knives, Ways and Rolls—Catalog, 58 pp. Shows those products above and more for use in machinery, metalworking, iron and steel, pulp and paper, woodworking industries. Tool Steel Gear & Pinion Co, Cincinnati 16.

(D-126) Chemical Milling—Brochure, 12 pp. Describes capabilities of the company and the technique where conventional methods are difficult or impossible. US Chemical Milling Corp, 1700 Rosecrans Ave, Manhattan Beach, Cal.

(D-127) Semi-automatic Mill—Bulletin, 4 pp. Describes a small, low cost production mill and attachments. Rotex Punch Co, Inc, 2350 Alvarado, San Leandro, Cal.

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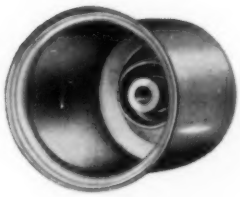

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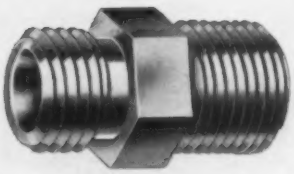

SCREW MACHINE PRODUCTS

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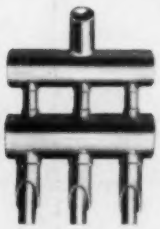

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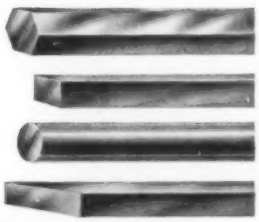

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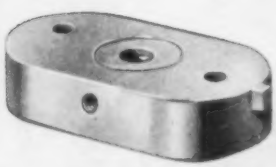

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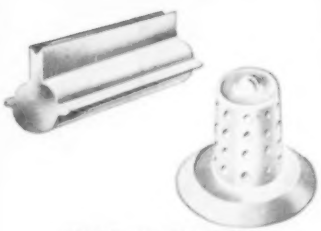

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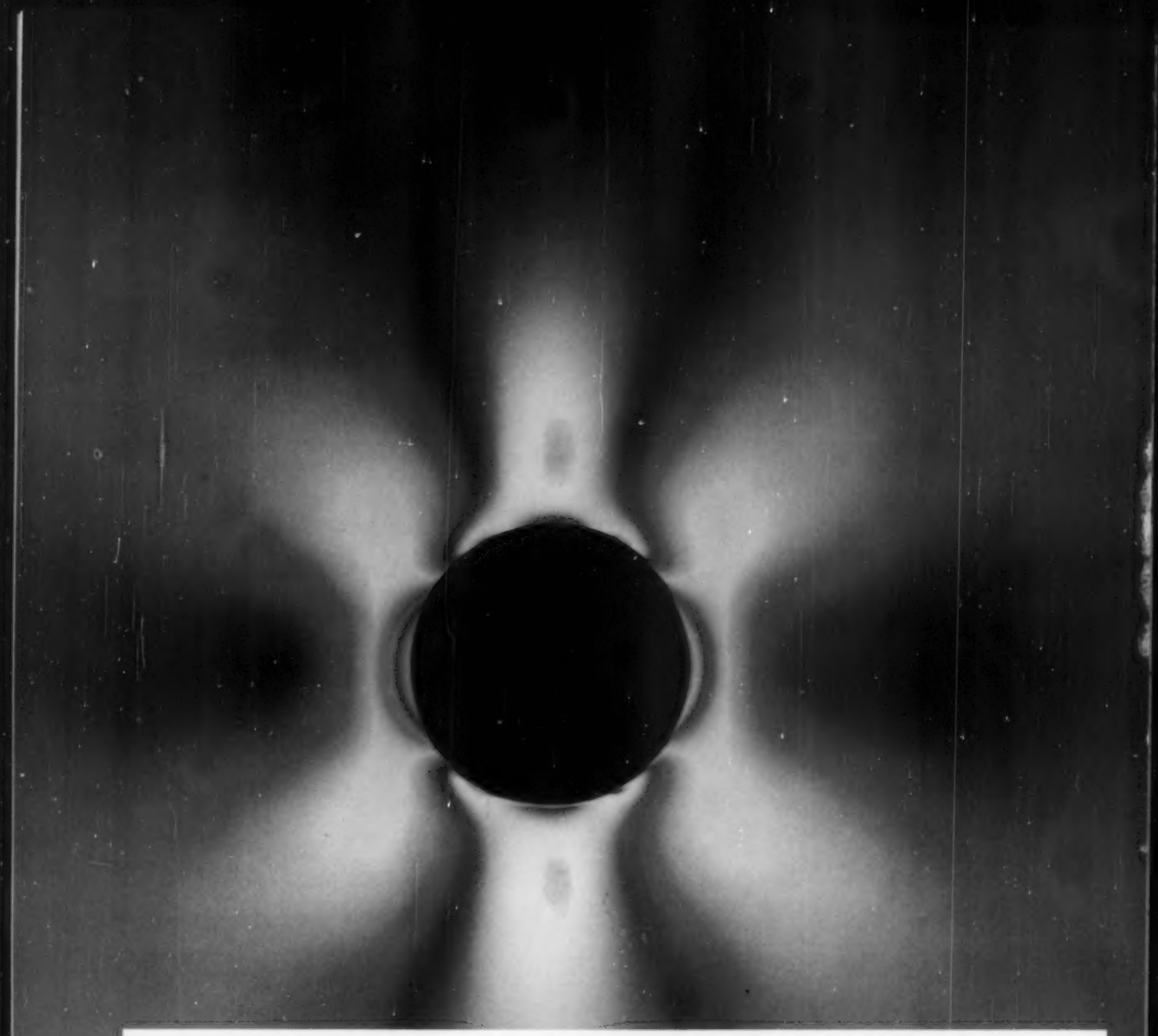


Photo-elastic stress patterns produced by models photographed with polarized light are one of the modern analytic tools available for ever-increasing perfection of Malleable iron castings.

For Greatest Strength Per Dollar... Use Malleable

To improve quality and cut costs, you'll find nothing better than Malleable iron castings. They provide more strength per dollar than any other metal, ferrous or non-ferrous! With Malleable you also get proven toughness, uniform quality and unsurpassed machinability.

See for yourself how much Malleable castings will improve your products and cut your costs. Send drawings or an outline of your requirements to a nearby Malleable castings producer who displays this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

For detailed information on "Strength Characteristics of Malleable Iron Castings", contact any of the progressive companies listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

"Value Analysis" Proves–

Malleable Castings Improve Quality, Reduce Costs

When "Value Analysis" is your task, consider these outstanding advantages of Malleable iron castings: more strength per dollar than any other metal, ferrous or non-ferrous; exceptional machinability; metal exactly and only where it is needed; job-proven toughness.

Wide Range of Desirable Properties Available in Malleable

Standard and pearlitic Malleable irons are available with strengths ranging from 50,000 p.s.i. to 120,000 p.s.i. tensile.

Note in this table the high ratio of yield strengths to tensile strengths — especially important to you because yield strength is generally the measure of useable strength.

TENSILE PROPERTIES—A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Yield as a Percent of Tensile
Standard			
35018	53,000	35,000	66
32510	50,000	32,500	65
Pearlitic			
45010	65,000	45,000	69
45007	68,000	45,000	66
48004	70,000	48,000	69
50007	75,000	50,000	67
53004	80,000	53,000	66
60003	80,000	60,000	75
80002	100,000	80,000	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

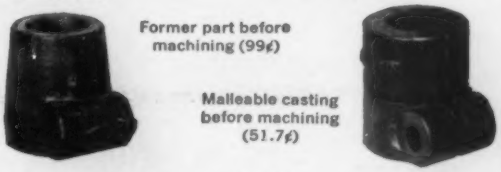
Other Mechanical Properties

	Standard	Pearlitic
Modulus of Elasticity in Tension, p.s.i.	25,000,000	26,000,000 — 28,000,000
Ratio of Fatigue Strength to Tensile Strength	0.54	0.40 — 0.50
Shear Strength — % of Tensile Strength	80 — 90%	70 — 85%
Torsional Strength	Approximately equal to Tensile Strength	
Compressive Strength, p.s.i.	200,000	250,000

Switch to Malleable Saves 47% on Railroad Car Thrust Collar

One of countless examples of cost reduction obtained by changing from other materials or processes to Malleable castings is this thrust collar used on railroad maintenance cars. While the steel part formerly used performed satisfactorily, it cost 99¢ before machining.

The cost of the standard Malleable casting before machining is only 51.7¢ — a saving of 47.3¢! Added to this, four machining operations — drilling of bolt hole, spot facing for bolt head and nut, milling the sleeve slot and sawing the transverse slot — were eliminated by switching to a casting. All remaining machining operations are improved due to Malleable's exceptional machinability.



Former part before machining (99¢)

Malleable casting before machining (51.7¢)

Cost-Saving Engineering Assistance Available

The kind of engineering assistance that cut costs and improved product quality for these companies and thousands of others is available to you from any of the progressive producers of Malleable castings that are members of the Malleable Castings Council. Start increasing your product profitability right now — contact any of the companies listed below.

Free Information Folder

Your copy of an informative folder, *Data Unit 110—Malleable Castings in the Value Analysis Spotlight*, is available free from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, or from any member company.

For Quality and Economy... Use MALLEABLE

For Service In Your Area Contact...

CONNECTICUT

Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE

Eastern Malleable Iron Co., Wilmington 99

ILLINOIS

Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA

Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA

Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS

Belcher Malleable Iron Co., Easton

MICHIGAN

Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA

Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI

Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE

Laconia Malleable Iron Co., Laconia

NEW YORK

Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division, Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO

American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA

Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS

Texas Foundries, Inc., Lufkin

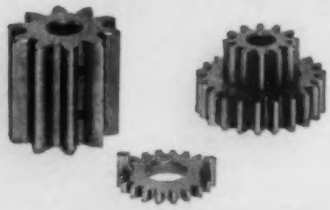
WEST VIRGINIA

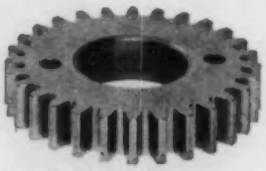
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN

Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

STEEL GEARS





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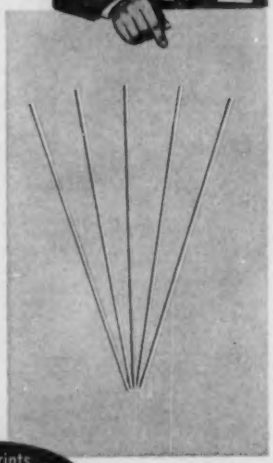

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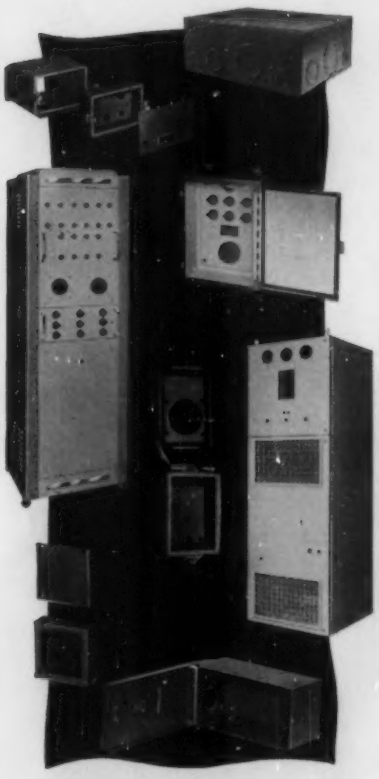

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catalogs and bulletins.....continued

(D-128) Polyethylene Annealing—Bulletin, 4 pp. Describes equipment and polyethylene film property changes caused by annealing. US Industrial Chemical Co, Div of National Distiller & Chemical Corp, 99 Park Ave, NYC 16.

(D-129) Toggle Clamps—Catalog, 16 pp. Presents over 80 dimensioned drawings of work holding clamps and pliers. Wespo Div, Vlier Engineering Corp, 26935 W Seven Mile Rd, Detroit 40.

(D-130) Clamps and Fixture Details—Catalog, 14 pp. Shows dimensions and drawing of components for making up jigs and fixtures without specially made parts. Wespo Div, Vlier Engineering Corp, 26935 W Seven Mile Rd, Detroit 40.

(D-131) Stampings—Brochure, 4 pp. Explains methods and capabilities for producing stampings in small quantities. WLS Stamping Co, 3292 E 80 St, Cleveland.

(D-132) Sheet Metal Fabricator—Catalog, 12 pp. Describes single station machine for punching, notching, nibbling. Suitable for up to medium production runs. Wales Strippit, Inc, Unit of Houdaille Industries, Inc, Akron, NY.

(D-133) End Mills—Brochure, 4 pp. Describes holders and end mills with 2 and 2½ in. shanks and cut diameters from 2 to 3 in. Weldon Tool Co, 3000 Woodhill Rd, Cleveland 4.

(D-134) Cutting Tools—Catalog, 32 pp. Describes milling, boring, contouring cutters, special tools and others. Wetmore Tool & Engineering Co, 5320 E Washington Blvd, Los Angeles 22.

(D-135) Planer and Matcher—Bulletin, 12 pp. Describes direct motor or belt driven machines for sizing and cutting profiles in lumber. Yates-American Machine Co, 729 Fourth St, Beloit, Wisc.

(D-136) Filters—Brochure, 6 pp. Presents filters, stills, separators, flotation gear to clean coolants, oils and solvents. US Hoffman Machinery Corp, Box 214, Eastwood Sta, Syracuse, NY.

(D-137) Cold Roll-forming—Catalog, 88 pp. Discusses scope, economics, advantages of process; capabilities of equipment. Provides information on designing for process. The Yoder Co, 5561 Walworth Ave, Cleveland 2.

(D-138) Heat Exchangers—Bulletin, 8 pp. Tables list dimensions, heat transfer and liquid flow data. Shells are of steel, straight tubes Admiralty metal. Yates-American Machine Co, Beloit, Wisc.

(D-139) Stainless Steel Heat Exchangers—Bulletin, 4 pp. One,. two and four-pass units have fixed bundles of 316 stainless. Yates-American Machine Co, Beloit, Wisc.

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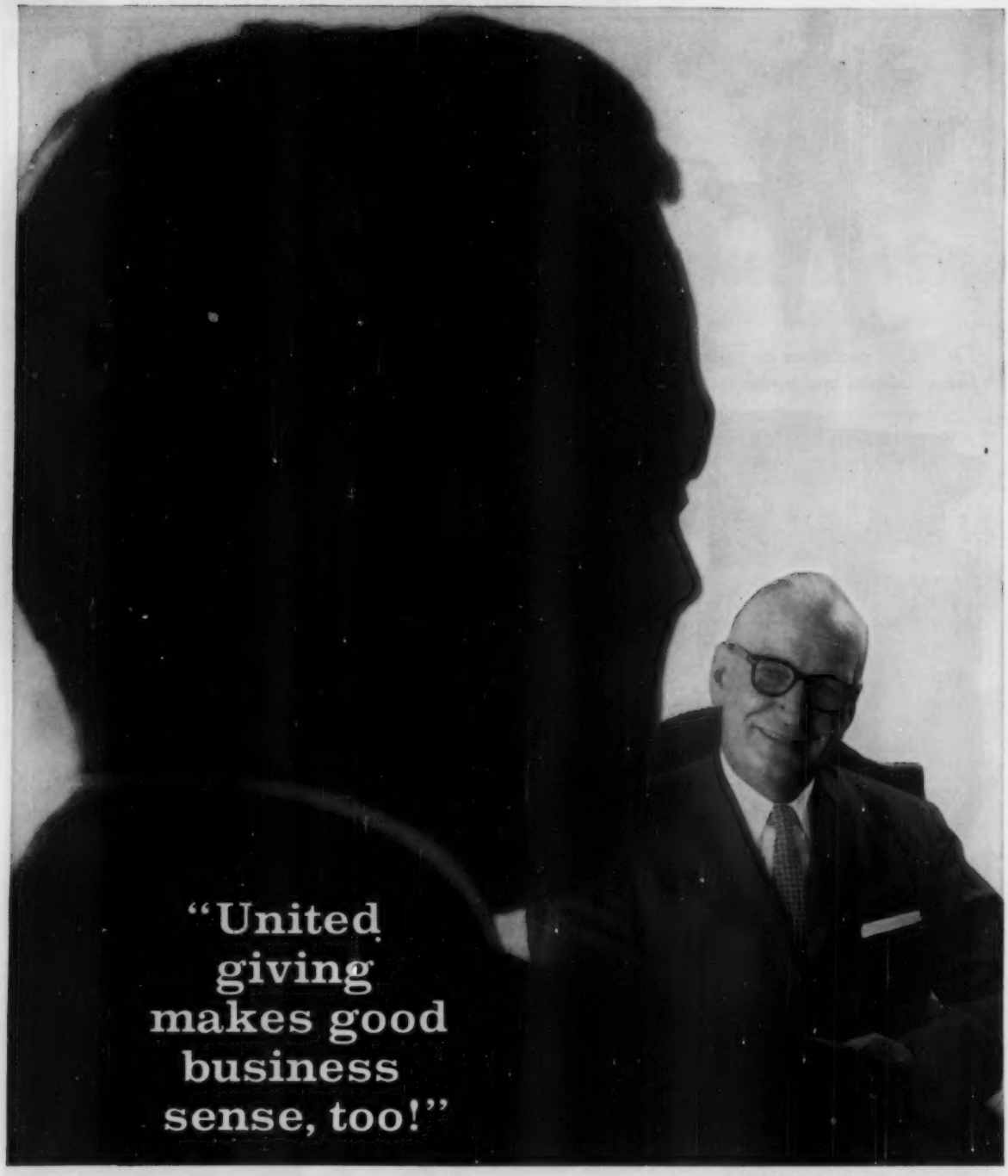


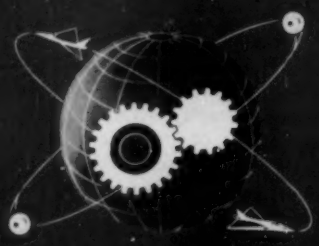
Every business has a vital stake in the welfare of its community. The businesslike way to protect these interests is to support your community The United Way. Your United Fund or Community Chest Campaign takes care of many community needs without the confusion and waste of separate appeals.

Your company can contribute in *three* important ways! ■ Make sure your company makes a generous corporate contribution. It helps protect the welfare of your employees and customers. ■ Help your employees meet their obligations through easy payroll payments. Experience shows this often doubles, even triples, results. ■ Stimulate executive participation in support of your local fund. Such participation helps safeguard the dollar investment made by your company and its employees.

Remember, giving The United Way helps your community *and* your company. **GIVE THE UNITED WAY**

SECTION E

POWER TRANSMISSION



Design Abstracts 200

6 Flexible Shaft-couplings
by R. Waring-Brown 202

Surveyed: 10 Lubrication Methods
by Allen F. Brewer 205

Belt Friction and Shaft Load
by O. R. Fendrich 208

Shot Peening in Gear Design
by J. C. Straub 210

6 Applications for the Capstan-type Power Amplifier
by L. A. Zahorsky 213

DESIGN ABSTRACTS

FITTING SINTERED BEARINGS

Porous metal bearings are much superior to solid bearing shells when service conditions preclude regular replenishment of lubricant, and thus find wide application in office machinery, domestic appliances and the like. Although the ability to operate for long periods without attention is the most obvious characteristic of porous bearings, and is usually the deciding factor in their adoption, they offer other substantial advantages. The installed cost of a porous bearing is nearly always less than that of a conventional solid bearing and, provided that the bearing is correctly chosen for service and is properly fitted, the actual bearing characteristics compare very favorably with those of solid ones.

This is particularly the case with light loads and high speeds, for although the starting torque is appreciably higher in the case of the porous bearing, the coefficient of friction under running conditions is consistently lower than that of the solid equivalent. The accepted parameter, viscosity X superficial velocity/load, is plotted against friction. The superiority of the porous bearing becomes more marked as velocity increases or load decreases. This highly favorable characteristic is attributable to the fact that, the surface being fed by capillarity, a porous bearing operates always under conditions of thin-film lubrication.

"Choosing and Fitting Porous Metal Bearings," Mechanical World, March 1960, 31 King St West, Manchester, England.

*

Synthetic Lubricant Research

This article presents briefly some of the elementary chemistry of synthetic oils and greases and brings the survey of synthetic lubricants up to date.

Literature published on synthetic lubricants is already enormous and shows no signs of diminishing its present rate of growth. To review even one class of synthetic lubricants in detail would require a sizeable volume. Of necessity this review touches on high points only.

"Synthetic Lubricant Research," Lubrication, November 1959, 135 East 42nd St, New York 17.

*

Strength-rating Helical Gears

After discussing factors for rating strength of helical gear teeth as applied in the formula developed by American Gear Manufacturers Assn's Gear Rating Committee, a new approach is described. This combines different concepts of geometry factors, an improved evaluation of dynamic loads, rational allowable stresses, risk or reliability considered as a statistical probability. Effects of operating error and load-distributing tooth flexibility are also included.

"An Analysis of Factors Used for Strength-rating Helical Gears," E. J. Wellauer, Falk Corp; ASME paper 59-A-121. ASME, 29 W 39th St, New York 18.

*

Gear-position Error

Recently, requirements for precision in such aspects of gear performance as control of angular position has revealed shortcomings in current terminology, specifications procedure, and inspection techniques. This paper discusses nature of position error and total composite error, their relative limitations and applications. Information is included on equating position and total composite error, and specification procedures for high-precision gears.

"Gear-position Error Control," George W. Michalec, General Precision Laboratory Inc; ASME paper 59-A-21. ASME, 29 W 39th St, New York 18.

*

Simplified Gear Calculations

Some of the methods useful in calculating dimensional aspects of gear design and production are reviewed. Some of the factors discussed include: the involute function; radians; calculation of distance over "N" teeth; calculation of distance over rollers when number of teeth is known; calculation of dimension over rollers when distance over old rollers is known. Some useful formulas for spur-gear proportioning are included, together with a table of involute function tables.

"Simplified Gear Calculations," Witham and Beveridge. Engineering Materials and Design, April '60, Drury House, Russell St, London WC 2, England.

*

Lubrication by Solids

Mechanism of lubrication is described and various types of solid lubricants are classified.

"Lubrication by Solids," J. Gaensheimer, Stamford, Conn; presented at Seminar on Friction, Lubrication and Wear, Burgenstock, Switzerland, Sept 17-18. Available from Alpha-Molykote Corp, Stamford, Conn.

*

Rolling Friction

The rolling friction of a hard cylinder over a viscoelastic material is worked out in terms of the bulk properties of the material. It is found that the rolling friction has a maximum at a velocity corresponding to the peak of the relaxation time distribution. Both the load required to maintain the cylinder at constant depth of identation and the coefficient of friction are dependent on the velocity of rolling. The shape of the rolling friction versus velocity curve is a first approximation to the distribution curve of relaxation times, indicating that rolling friction measurements can be used to determine the distribution experimentally.

"Rolling Friction of a Hard Cylinder Over a Viscoelastic Material," W. D. May, E. L. Morris and D. Atack. Pulp and Paper Research Institute of Canada. Journal of Applied Physics, Nov '59, 335 E 45th St, New York 17.

*

Thermal Instability in High-speed Gearing

A theory of thermal instability is developed which takes into account tendency of effects to be regenerative,

and which provides an explanation for several previously unexplained cases of tooth failure in highspeed, high-horsepower reduction gearing. Includes experimental verification and describes some of the means of avoiding thermal instability.

"Thermal Instability of High-speed Gearing," Welch and Boron, Westinghouse Electric Corp; ASME paper 59-A-118. ASME, 29 W 39th St, New York 18.

*

Open-gear Lubrication

Open gearing, such as is found in rotary kilns, cranes and shovels, draglines, chain and sprocket drives, and the problems of providing proper lubrication of this type of exposed equipment are described. Included are discussions of the relationship between composition and performance of lubricants, development of laboratory methods to evaluate improved lubricants, and comments on field performance of new lubricants.

"A Study of Open-gear Lubrication," Daniels and Malloy, Esso Standard Oil Co. NLGI Spokesman, Feb '60. National Lubricating Grease Institute, 4638 J. C. Nichols Parkway, Kansas City 12, Mo.

*

Epicyclic Gear Trains

Develops a method of synthesizing compound epicyclic trains using the concept of a velocity ratio spectrum. To facilitate application, only one train in a compound epicyclic train is regarded as basic; all others are considered as serving to modify motion of controlling element in basic train.

"Synthesis of Epicyclic Gear Trains Using the Velocity Ratio Spectrum," R. C. Brewer, University of London, England; ASME paper 59-A-22. ASME, 29 W 39th St, New York 18.

*

Noncircular Gears and Cams

First the theory of rolling curves and noncircular gears as it is involved in linkwork, gears, cams and similar systems is discussed, with equations presented for velocity ratio, tangential and rubbing velocities. Then the three types of design problems commonly involved are given: to design the follower to suit the driver; to design the driver and follower to a particularly velocity ratio; to design the driver and follower to a particular displacement function. Brief, separate discussions are included of noncircular, eccentric, elliptical, logarithmic, displacement and rack gears.

"Rolling Curves and Noncircular Gears," W. H. Sheppard. Mechanical World and Engineering Record, Jan '60, 31 King St W 3, Manchester, England.

*

Lubricant Tests

This paper discusses the significance of the following tests: water, insolubles, sulfur, copper-strip corrosion, analine point, interfacial tension, dielectric strength, and turbine-oil emulsion.

"Significance of Specific Lubricant Tests," Texas Co; Lubrication Engineering, Oct '59, 135 E 42nd St, New York 17.

*

The Bending Strength of Gear Teeth

Presents a study of the bending strength of gear teeth based on a cantilever-plate approach. Semi-empirical solution is given for finite cantilever plate under transverse loads at any location on its surface. Solution is said to have showed good agreement with results from strain-gage investigations of such plates simulating gear teeth. Effects of the position of the line load and the variation of load intensity on stress distribution at a root are discussed.

"Bending Strength of Gear Teeth by Cantilever Plate Theory," Wellauer and Seireg, Falk Corp; ASME paper 59-A-50. ASME, 29 W 39th St, New York 18.

*

Lubricants and Friction

Cases where surface-active lubricants increase rather than decrease wear are described and explanation based on chemical interactions is given. Experimental setup and procedure are described. Lubricants used in study were transformer oil containing stearic acid and water with soap containing 72% sodium oleate. Results of friction tests are included, based on time to failure of wire specimens and by weight loss of pulleys in contact with wire specimens.

"Effect of Lubricants on Process of Friction," V. D. Kuzinetsov and others, Transactions of Akadimiya Nauk, 1956, Vol 109, No. 1, USSR. Translation available from Henry Brutcher, PO Box 157, Altadena, Calif.

*

Lubricating-grease Properties

One of the factors affecting properties of lubricating grease is the size and shape of the thickener particles. The effect of the length-to-width ratio of these particles on mechanical stability, age-hardening, and leakage of grease was studied. Four greases were made from lithium hydroxy stearate and a mineral oil. The greases were alike in thickener concentration and consistency but differed in thickener-particle dimensions as measured from electron micrographs. Increases in length-to-width increased mechanical stability and leakage and reduced age-hardening. Although observed only with lithium-soap greases, the same trends should occur with other greases.

"Effect of Thickener-particle Dimensions on Lubricating-grease Properties," A. C. Borg and R. H. Leet, Standard Oil Co, Whiting, Ind; Lubrication Engineering, Nov '59, 5 N Wabash Ave, Chicago 2.

*

Bearings, Lubricants and Lubrication

An annotated listing of 277 papers delivered during 1958 is presented under the following categories: fluid film bearings, ball and roller bearings, friction and wear, automative lubricants, metalworking lubrication, lubricant properties. A bibliography of these papers is broken down in a similar manner. It is thus made easy to trace other references.

"Bearings, Lubricants and Lubrication—A Digest of 1958 Literature," by Elwell, Lewis, Shugarts, et al. Mechanical Engineering, Oct 1959, ASME, 29 W 39 St, New York 18.

From: Mechanical World

6 FLEXIBLE SHAFT-COUPLINGS

Practical information on wobbler, flexible dog, laminated spring, bevel drive, spring pin and multi-spring couplings.

R. WARING-BROWN
Consulting Engineer
Anglesey, Gt Britain

It is frequently necessary, particularly with automation equipment, to couple shafts flexibly. This often occurs where dimensions of length and diameter are restricted and the use of standard coupling units is precluded and therefore couplings have to be specially designed.

Modern research indicates that every shaft coupling should provide some degree of flexibility, and while this may introduce some complexity with modern ideas and using modern materials it is far from impossible.

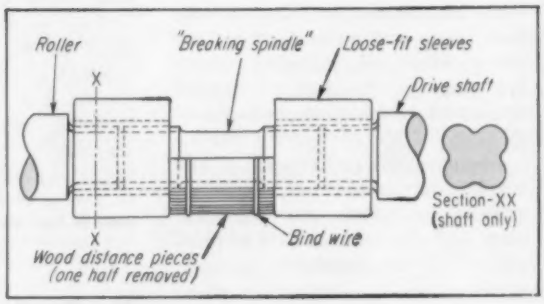
Our present purpose is to consider shaft couplings which are limited in external diameter and which must provide flexibility to cope with axial, radial and angular misalignments to obtain high efficiency and obviate noise and vibration. Further, due regard must be given to maintenance and adjustment.

Satisfactory selection of the shaft coupling depends upon the particular conditions under which it has to operate and the type of machinery involved, and is ultimately founded on experience. Below are given a few examples of current practice and modern ideas, where coupling diameters are comparatively small compared with shaft size.

WOBBLER COUPLINGS

Although a crude design, these couplings have qualities which make them unrivalled in the presence of considerable grit, water, steam and heat. In Fig. 1 is illustrated an assembly as adopted in steel rolling mills. It acts as a connection between a driving pinion and its corresponding roll. It will be seen that a "breaking spindle" is used which is designed to avoid other and more serious damage by fracture damage to fracture under the severe overload to which such equipment is often subjected.

The ends of the roller and the pinion shaft are of special section, in some instances resembling a four-leaved clover, variants being of cruciform construction. The ends of the breaking spindle are similarly loosely fitting sleeves. In the final assembly the two sleeves are held apart by pieces of wood placed in the grooves of the breaking spindle and bound together by wire, the great advantage of this primitive locking device being that it can be quickly dismounted and replaced at negligible cost.



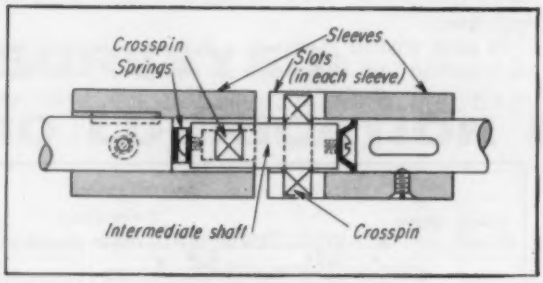
1. . **WOBBLER** flexible coupling.

The work such couplings are called on to perform is extremely arduous, but limited flexibility in any direction is attained at the expense of a fair amount of noise. However, this is not objectionable in the class of work involved, and excessive noise and vibration will not develop when the coupling is correctly designed to transmit the optimum torque. By sliding one of the sleeves toward the other, the overall length of the breaking spindle may be kept down to a dimension sufficient to permit its easy removal for severing the connection between the driving pinion and the roll.

A refined construction founded on the basic principle could be used in small mechanisms.

FLEXIBLE DOG COUPLINGS

Efforts to devise a simple and effective flexible coupling have resulted in the scheme illustrated in Fig. 2. This compact arrangement, while allowing limited flexibility in the various directions, satisfies the paramount consideration of small diameter. The component has a minimum of parts and has good anti-vibration qualities. The two shafts to be coupled carry keys to drive sleeves, which are held in position endwise by grub screws, the inner ends of the sleeves being provided with slots at right angles to each other. There is an intermediate shaft to the ends of which are fitted two special springs held in posi-



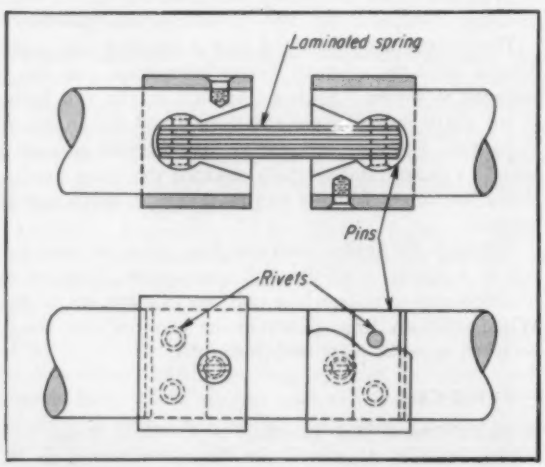
2. . FLEXIBLE dog coupling.

tion by screws, these springs being arranged to maintain contact between the driving and driven shafts at all times, thereby eliminating end movement, shock and vibration. At a little distance from the ends of the shaft two holes are drilled at 180°, and cross pins, formed with dog ends, are fitted to give a good sliding fit in the slots of the coupling sleeves. The intermediate shaft should be given a good clearance on the inside of the sleeves, and a gap of about ¼ in. should be allowed between the inner ends of the sleeves so that reasonable flexture and end motion may be accommodated. The coupling sleeves should be capable of being slid back on their keys for dismounting, while the springs to distribute the end pressure should have small arms, or alternatively a Belleville washer may be utilized.

This coupling has proved very satisfactory in practice over long periods of service.

LAMINATED SPRING COUPLING

It is sometimes advisable to install a shaft coupling in a limited space that will give improved flexibility, even though it is more expensive to produce. In Fig. 3 is illustrated a type that comes into this category, and it will be seen that the two shafts to be connected have their inner ends slotted out into holes drilled through the shafts, which latter take comparatively large diameter pins. These pins



3. . LAMINATED spring flexible coupling.

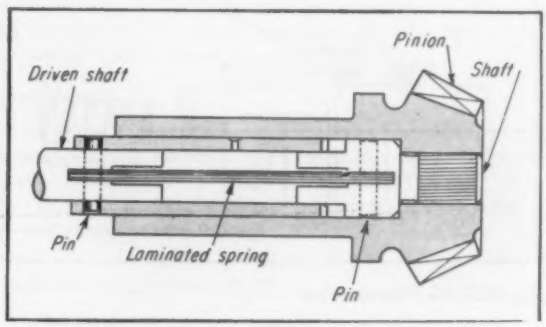
are also slotted to take a series of laminated spring plates which are fastened by rivets.

The pins are hardened and ground and are slid into place in the shafts. Sleeves protect the pins, preserving a smooth finish without projections on the finished assembly. The coupling was primarily designed for textile machinery to eliminate keys and to transmit the drive but not vibration. It is easily disassembled.

LAMINATED SPRING BEVEL DRIVE COUPLING

In high-class work improved forms of the laminated spring coupling are being very successfully applied. In Fig. 4 is illustrated such an assembly utilized to drive an engine governor. A bevel pinion is splined to a shaft which is slotted to take a laminated spring, similarly connected at its other end to the driven shaft. The spring is firmly fixed to the bevel shaft and driven shaft by pins forced in under pressure. Slight axial movement is allowed, and a positive abutment drive is also provided. It is often necessary to detach a driven unit from a prime mover; this design facilitates this.

Another important feature is avoiding the transmission



4. . LAMINATED spring bevel drive coupling.

of cyclic variations, and here an improvement consists in making the slots in the shaft ends just wide enough to give sufficient clearance to the laminated spring to allow of some deflexion during operation, so that when the spring attains a resonant condition its increased deflection will bring the spring plates up to the edges of the slots, thereby shortening their effective length and immediately detuning the system.

In such a scheme misalignment is not allowed, but flexibility in transmission effectively eliminates vibration and noise. A positive abutment drive is also provided to prevent overstressing the spring plates during overload. To prevent cyclic variation it would be possible to incorporate some form of rubber coupling, but as these generally have a fixed natural frequency of oscillation, they would not prove satisfactory in the coupling required for the particular purpose of the bevel drive described.

The coupling arrangement is simple and compact while being easily dismountable, but it must be precision built. In certain cases it is sometimes advisable to arrange for the abutment drive to engage after only a slight deflection of the spring.

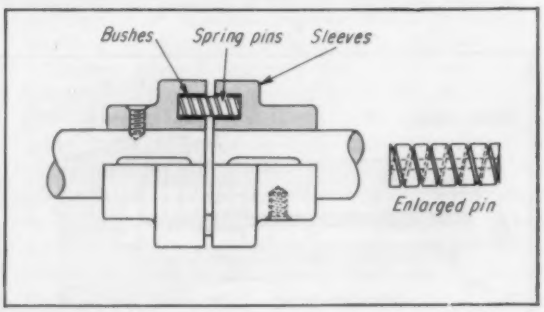
SPRING PIN COUPLING

At times it is absolutely essential to connect shafts by a coupling capable of dealing with slight deviations in shaft alignment, as for instance in coupling steam turbines, or internal combustion engines to blowers, or other equipment where high speeds of rotation are involved. Fig. 5 illustrates a coupling specially developed to operate at high speeds, and in order to render it suitable the dimensions are kept down to a minimum by making the several working parts of high-duty steel, hardened and ground.

The spring pins are tempered steel helical springs of abnormal section, having a very small hole in the middle.

In the sketch two coupling sleeves are shown fitted to the driving shafts with keys, and are retained horizontally by grub screws. The coupling sleeves have a series of holes drilled in their faces and hardened steel bushes are pressed in. Helical springs are located in the pockets thus formed, and are sufficient in number, flexibility and strength to transmit the required torque by shearing action.

Any flange coupling connecting two shafts that are out of alignment will run open on one side and closed on the other. The endwise motion due to this opening and closing action of the flanges is provided for in this coupling by the universal flexibility of the pins and the fact that the minute clearance between the coils, together with the initial compression put upon them, will accommodate their opening and closing movement.



5. . **SPRING PIN** coupling.

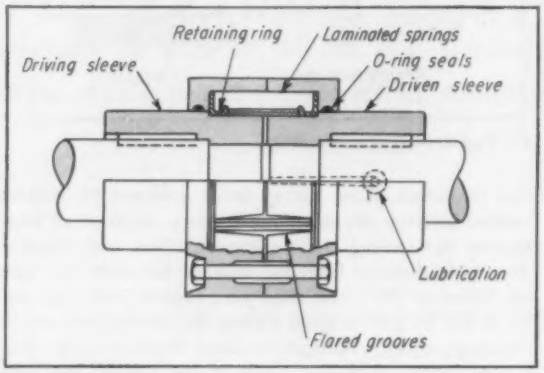
In practice this scheme has shown a natural propensity for damping out vibration, and also its durability, especially when charged with grease in the central cavities of the spring pins. This coupling exemplifies simplicity in mounting, dismantling and maintenance, while safety is assisted by the smooth exterior, and the diameter is down to a minimum.

MULTI-SPRING COUPLING

For certain classes of machinery couplings are required which give a greater flexibility while catering for the various types of shaft misalignment and simultaneously providing a cushioned drive; although the objective may be difficult to attain without instituting somewhat larger diameters for the coupling, and in addition without rendering the unit unduly expensive.

Fig. 6 illustrates a design whose special requirements are not excessive, and is in fact a coupling with multiple laminated springs constructed to deal with high torque and high speed.

In most modern machinery anti-friction bearings play an important part: in consequence any considerable errors in alignment, whether originating from wear, faulty erection, settling of foundations etc., will set up strains and stresses which will subject shafts and bearings to overloads, which may result in increased friction, loss of power, and often to ultimate fracture of parts.



6. . **MULTI-LAMINATED** spring coupling.

This coupling provides for a flexible connection between driving and driven shafts, will transmit high powers, and is eminently suitable for dealing with shock and vibration. The coupling consists of driving and driven sleeves keyed to the coupling shafts, the hubs carrying a series of laminated springs in accurately pitched grooves. These latter are flared so that the springs are adequately supported under load while retaining their resilience, being also held in position by retaining rings. The two halves J and K of the outer casing are held together by bolts passing through the hubs.

The retaining rings are spigoted together, and so formed as to fit and locate the springs independently of the hubs, to ensure freedom of the latter to take up misalignment.

The successful operation of such a coupling will largely depend upon the adequate grease lubrication, and this is arranged as shown. Seals are located in the two halves of the outer casing to prevent leakage and the ingress of impurities. Bolts are recessed so that the unit presents a smooth exterior, and specially selected steels are used so that a minimum diameter and maximum strength may be ensured.

Although the flexible shaft-couplings presented here may not be available as off-the-shelf components, they are all relatively easy to make where only one or a few are needed. When relatively large quantities are involved care should be taken to make parts interchangeable.

REFERENCE:

Restricted Flexible Shaft Couplings by R. Waring-Brown, Consulting Engineer, Anglesey, Great Britain. Published in Mechanical World, July '59, p. 303.

From: Lubrication Engineering

SURVEYED: 10 LUBRICATION METHODS

Here is an illustrated roundup of basic arrangements for lubricating machine elements.

ALLEN F BREWER
Lubrication Consultant

After the designer has chosen one of the lubrication methods surveyed below, it is his responsibility to use it to the best advantage. Here is a checklist of standards against which the designer can compare the lubrication system and judge its effectiveness.

Accessibility

Nonautomatic devices depend on faithful servicing. Hard-to-get-at reservoirs or fittings that discourage faithful attention lead to breakdowns with their companions, down time, parts replacement and repair charges.

Any device, even an automatic one, needs to be cleaned. But if out of reach, the device will soon be out of sight under dirt, thus even less likely to get proper attention.

Safety

Safe lubrication deserves just as much concern as designers give safe machinery operation. Besides being a possible cause of injury, an unsafe lubrication system detracts from the efficiency of the machine. Operators avoid risky lubrication points, so that sooner or later the machine will have to be shut down for each lubrication.

Reliability

Human element. To increase reliability, decrease dependence on human beings. Acts that require judgment are most prone to error. When the designer can't eliminate the human factor entirely, he can sometimes eliminate acts of judgment. For instance, use a device that regulates how much oil and how often applied so that the operator just has to fill a reservoir.

Automatic devices that use the machine itself as a power source for circulation drive out dependence on humans to the minimum. When the machine starts and stops, oil flow starts and stops.

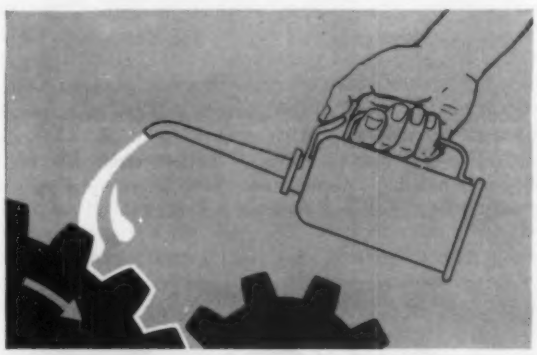
Dirt in the lubricant will wear out a bearing; but dirt can also cause trouble by clogging lines or valves and stopping flow. There are two ways to prevent this: Keep dirt out with seals, covers or filters; overcome clogging with positive pressure—as clogging builds up, pressure builds up to free stoppage.

Leakage

Leakage is intolerable in industries like foods and textiles where contamination of product means its loss. In any industry leakage of slippery, inflammable lubricants is a safety hazard. Furthermore, leakage is uneconomical, not only because of the cost of lubricants, but also because of the money spent cleaning it up.

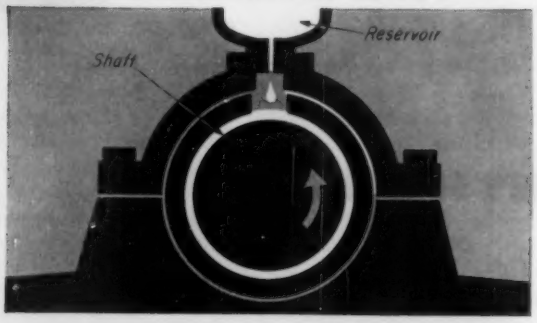
Consistency

Consistency means keeping the design simple by using as few different lubrication devices and as few different types of lubricants as possible. Standardizing like this throughout a design will allow greater familiarity with a limited number of devices by maintenance men. A further advantage is the smaller inventory of spare parts and lubricants that must be kept on hand.



Manual lubrication methods generally result in high maintenance costs, poor reliability, sloppy housekeeping and uncertain regulation of flow. This method is also nonadaptable, noncontinuous and prone to contamination. The main advantage is low initial cost.

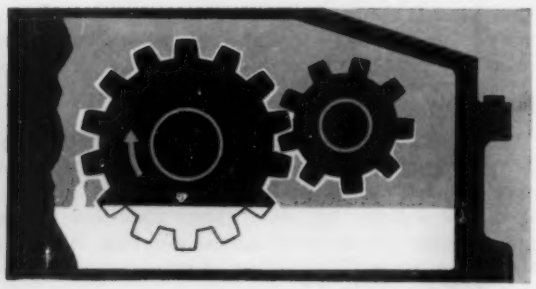
Applications: Lightly loaded or low-speed bearings, infrequently operated machinery, open gears, chains and wire rope, and other inexpensive or rough machinery.



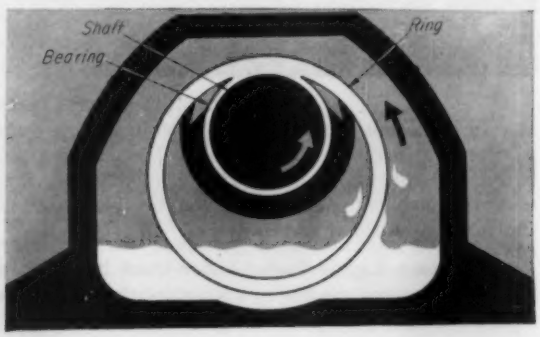
Drop feed oilers deliver lubricant by gravity to individual points which, ideally, are few in number and accessible. Under ideal conditions a well-thought-out automatic system can give reliable, regulated flow and low maintenance costs.

This system, however, is nonadaptable, and flow varies with oil level.

Applications: Journal and roller bearings, gears, chains, engine guides, pumps, compressors and pillow blocks.



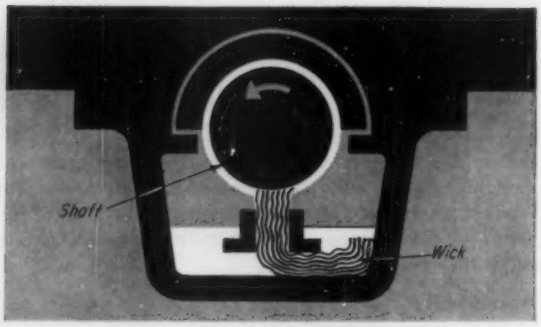
Splash or bath lubrication is suitable for machinery with enclosed high-speed moving parts. Enclosure and sealing determines initial cost, but insures against contamination. Maintenance costs, oil consumption and operator time, all of which contribute to operating expense, are low. Other advantages are reliability and flow, which is uniform, continuous and adaptable to changes in speed. By changing the oil level or adding scoops or dippers, crude flow regulation is possible. Applications: Internal combustion engines, chain drives and enclosed gear sets.



Ring, Chain and Collar Oilers feature loosely hanging rings or chains or rigidly mounted collars that ride on rotating horizontal shafts. The rider dips into an oil reservoir and carries oil to the bearing surfaces.

Low consumption and noncontamination keep operating and maintenance costs low. Initial cost depends on the bearing housing. When correct oil level is maintained, reliability is good, and flow is uniform, increases with speed, starts and stops automatically and is continuous but unregulated.

Applications: Electric motors, fans, blowers, compressors and line shaft bearings.

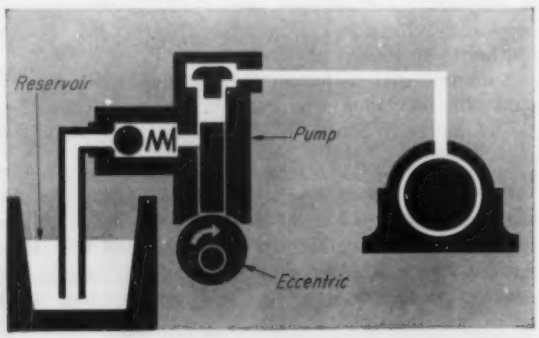


Pad and wick devices make use of the oil retaining properties of felt pads and waste packing to provide a lubricant source. One type uses a wick to carry oil by capillary action from a reservoir to the journal surface that wipes the wick.

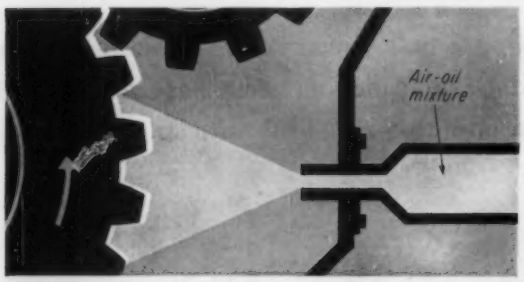
Generally these devices require a simpler housing, keeping initial cost low. In a clean environment maintenance is low. A dirty atmosphere requires inspection for clogging or glazing of the wick, although the wicking does tend to filter out contaminants. Flow is continuous, automatic, and varies with speed, but can be regulated only by changing reservoir level.

Applications: Railroad and traction motor bearings.

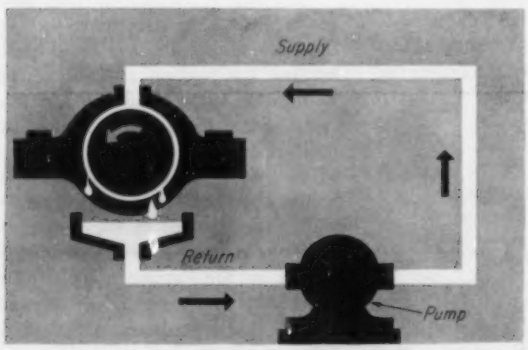
In pad devices all the oil is held by the pad, there being no sump. This simplifies the housing and lowers initial cost. If relubrication is unnecessary, maintenance costs are cut. Flow is automatic, but drops off with decreasing pad saturation, and is lower than in a wick and reservoir system. Applications: Fhp motors and home appliances.



Positive force feed has a separate drive motor, or the machine itself drives plunger-type, adjustable-stroke pumps drawing from a single reservoir. Low maintenance cost plus contamination protection balance high initial cost. Oil flows one way only; to avoid high oil consumption and constant reservoir topping, use positive force feed where oil demand is low. Flow is periodic, uniform, automatic, can be made proportional to speed, and is finely adjustable by changing pump stroke. Applications: Steam cylinders, diesel and gas engine bearings, oil drill rigs, glass making machines and press bearings.

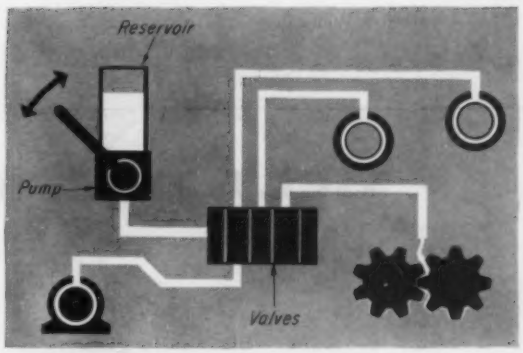


Air-oil mist devices employ air or steam to carry oil injected or drawn into the air stream to the bearing surface. Although piping, reservoir and compressed air supply make initial cost high, maintenance is low. The designer can build in flow regulation and automatic start and stop. Since this is a once-through system, all oil delivered is consumed and the possibility of contamination is slight. Applications: High-speed plain or rolling contact bearings, enclosed gears, chains, slides, guides and table ways.



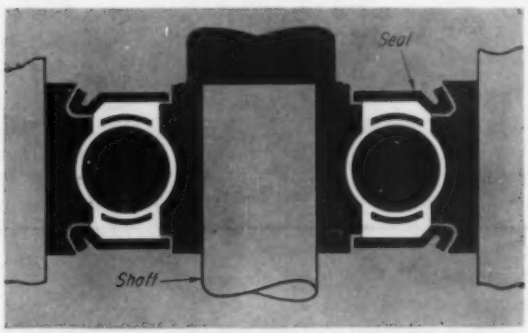
Pressure circulation involves an expensive system of pipes, controls, filters, coolers, and separators through which a central pump or gravity pressure source delivers oil to several bearings which are costly and critical enough to justify the system. In return for initial high cost, pressure circulation delivers a continuous, uniform, regulated flow of clean oil. Maintenance costs are low, and the operator need only make routine inspections and add occasional make-up oil.

Applications: Steam turbine bearings, reduction gears, steel mill gear drives, and mill bearings, paper machine bearings and gears, and internal combustion engines.



Centralized systems give one-shot manual or periodic automatic delivery of either oil or grease. Safety, both a humane and a cost factor, is the aim where lubrication points are dangerous to reach. When a machine has a large number of lubrication points, a centralized system reduces operator time and chances of a missed fitting. These advantages outweigh high outlays for a reservoir, pump, piping and regulating valves. A centralized system also meets the tests of dependability, durability, uniformity of delivery and protection from contamination.

Applications: Machine tools, woodworking machinery, steel and paper mill equipment.



Built-in lubrication includes two different cases: Materials that don't need lubricant, and prelubricated bearings that need no further attention. Nylon, PTFE, graphite and diamond can rub together with low friction without the necessity of an added lubricant. Sleeve bearings, gears, bearing blocks, jewelled bearings are typical places where these materials find jobs. In the second category are oil saturated porous metals, and sealed ball bearings. Applications: Design where space or cost requirements rule out extra lubricating apparatus, or when total lack of maintenance is likely or desirable—but don't overtax built-in lubrication, ensure that conditions are not too severe.

REFERENCE:

A Survey of Lubrication Methods by Allen F. Brewer, Consultant. Published in Lubrication Engineering, April 1960, p 153-156.

From: Mechanical World

BELT FRICTION and SHAFT LOAD

The total load on a pulley shaft due to belt tensions is analyzed for static, limiting and normal operating conditions. The variation of this load with angle of lap is illustrated.

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Lecturer in Mechanical Engineering
Battersea College of Technology

If a belt is to be used to transmit power, it is necessary to provide a uniform static or "initial" tension before the drive is taken up. The resultant force on the shaft will then be

$$P_o = 2T_o \sin \tfrac{1}{2}\theta$$

Where

T_o = initial tension.
θ = angle of lap.

The line of action P_o will pass through the point of intersection of the end tensions, and also through the pulley center as shown in Fig. 1.

When the drive is taken up, the tension on one side of the belt will increase while that on the other side will decrease until the torque produced by the tension difference is sufficient to overcome the external resisting torque on the driven pulley. This tension difference reaches its greatest value when the belt begins to slip bodily over the pulley surface. If the tight side tension = T_1 and the slack side tension = T_2 then, for the limiting conditions described, and assuming a thin flat belt,

$$T_1/T_2 = e^{\mu\theta}$$

where μ = coefficient of friction between belt and pulley (assumed uniform).

The effect on the resultant pulley load P is shown in Fig. 2.

$$P = \sqrt{T_1^2 + T_2^2 - 2T_1 T_2 \cos\theta}$$
$$= T_2 \sqrt{e^{2\mu\theta} + 1 - 2e^{\mu\theta}\cos\theta}$$

and its line of action, though still passing through the intersection of the lines of action of T_1 and T_2, is now displaced from the pulley center by a distance d. Since the torque on the pulley due to the belt tensions is $(T_1 - T_2)R$ it follows that

$$Pd = (T_1 - T_2)R$$

and hence

$$d = (T_1 - T_2)R/P$$

where

R = pulley radius.

$(T_1 - T_2)$ is the tangential friction force between belt and pulley so that the ratio $(T_1 - T_2)/P$ indicates the "efficiency" with which the total shaft load P is utilized as useful driving force.

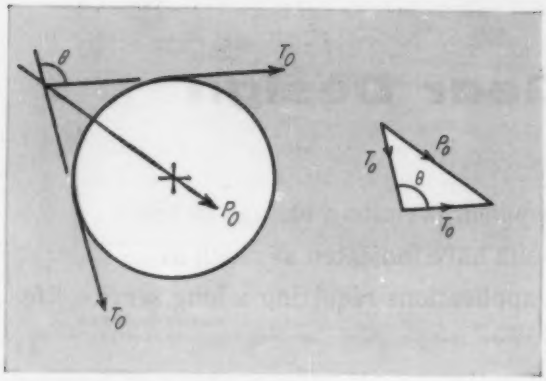
Graphs of P and $(T_1 - T_2)/P$ against θ for various values of μ are shown in Figs. 3 and 4, the graphs being plotted for $T_2 = 10$.

In Fig. 3 it should be noted that for low values of μ the slope of the curve alternates between positive and negative while for the higher values the slope is always positive. It can be shown that the limiting value of μ from this point of view (i.e., the least value of μ for which the slope of the P curve is never negative) is about 0.275.

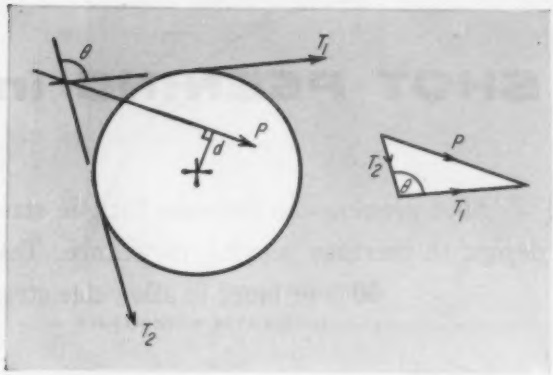
Normal Operating Conditions

In a belt drive transmitting power under ordinary conditions the belt does not slip bodily over either pulley because the friction has not reached its limiting value at all points of contact. Experiments have shown that limiting friction exists at only a part of the arc of contact. This part extends backward from the point at which the belt leaves the pulley and subtends at the pulley center an angle known as the "active angle." This angle has the same value for both pulleys of a belt drive; so that if the active angle = β, then $T_1/T_2 = e^{\mu\beta}$ for each pulley. The change in the belt tension from T_1 to T_2 (or vice versa) takes place while the belt is passing over the region of limiting friction. There is a constant tension in that part of the belt which covers the remainder of the arc of contact.

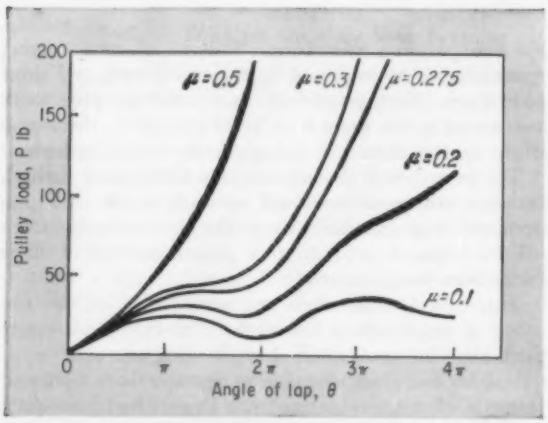
Under these conditions, a correction must be made to the values of μ before using graphs such as those in Figs. 3 and 4. If the actual coefficient of friction between belt and pulley is μ



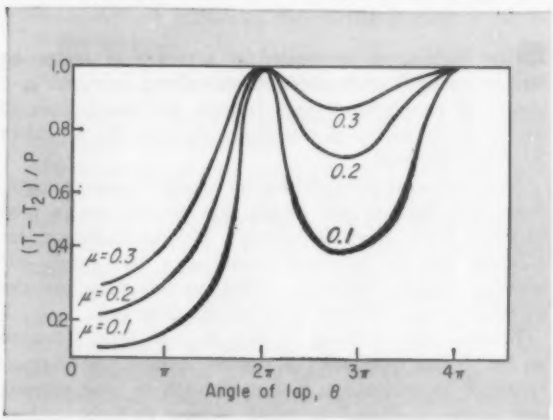
1—STATIC BELT CONDITION. The resultant passes through the pulley center.



2—DRIVING CONDITION. The resultant is at a distance from the pulley center.



3—VARIATION OF RESULTANT with angle of lap for various values of coefficient of friction.



4—VARIATION OF "EFFICIENCY" of load utilization with angle of lap.

then the graph to be used will be that corresponding to a value of the coefficient equal to μ (β/θ) where θ is the total angle of lap.

General

(a) Belt inertia—In the case of a belt drive running at speed, the effective tensions T_1 and T_2 which have been used in the analysis above, are smaller than the total tight side and slack side tensions respectively; the remainder is required to give the belt the necessary centripetal acceleration as it passes over the curve of the pulleys. The relevant relations then are:

$$T_1 = T_t - (wv^2/g)$$

and

$$T_2 = T_s - (wv^2/g)$$

where

T_t = total tight side tension
T_s = total slack side tension
w = weight of belt per unit length
v = belt speed, fps

(b) Grooved pulleys—A belt running in a groove of included angle 2α with a coefficient μ is equivalent, for friction purposes, to a flat belt with the same angle of lap and a coefficient of friction equal to $\mu/\sin\alpha$.

Service Factors

The hp transmitted by a rubber belt with 180° contact arc is given by

$$hp = WSP/2400$$

where W is belt width, in., S is belt speed, fpm, and P is the number of plies. When the small pulley is less than 12 in. dia the hp transmitted should be multiplied by the following factors as recommended by B. F. Goodrich Co:

small pulley dia	10	8	6	4	3
correction factor	0.9	0.8	0.7	0.6	0.5

For contact arcs other than 180° the following correction factors apply:

contact arc, deg	140	160	200	220
correction factor	0.80	0.90	1.08	1.15

For speeds above 6000 fpm always check with the belt manufacturer since centrifugal tension and belt heating can result in wide variations from calculated performance.

REFERENCE:
Belt Friction and Shaft Load by O. R. Fendrich, Lecturer in Mechanical Engineering, Battersea College of Technology, London, England. Published in Mechanical World, Dec. '59, p. 504.

From: Lubrication Engineering

SHOT PEENING in Gear Design

Shot peening can increase fatigue strength which permits a change in tooth design to increase scoring resistance. Test results have indicated as much as 50% or more in allowable stress in applications requiring a long service life.

J. C. STRAUB
Wheelabrator Corp.
Mishawaka, Ind.

Shot peening is recognized as a means of increasing fatigue strength of machine parts. Long accepted as a means of correcting fatigue failures, the possibilities of its use in the design of machine parts generally appear to be underestimated.

Although used primarily for increasing fatigue strength, if incorporated into gear design, shot peening can be used to avoid other types of failure. Scoring resistance, for example, may be increased by use of a finer pitch, but bending strength decreases. Shot peening may give the necessary fatigue strength to offset this decrease.

Directly, shot peening appears to have little influence on the scoring tendencies of a given physical pair of gears. However, an increase in fatigue strength by shot peening can permit a change in tooth design to favor scoring resistance.

Relationship of Design Factors

For effective use of material in the design of gears, the three types of failure, Table I, should be considered. If the power is transmitted at a high torque and low speed, scoring resistance may not be a problem. If high speed is used, scoring resistance becomes an important factor.

However, if size and weight of the transmission are to be reduced, the three types of failure must be balanced to achieve a good design. Resistance to bending failure depends, at least in part, on the tooth thickness. In contrast, both pitting and scoring are the result of surface condition, and are not influenced directly by tooth thickness. These types of failure are strongly influenced by the radii of curvature of the tooth profile in the area of contact, since contact stress increases with decreasing radii of curvature.

The capacity for trouble-free performance of a pair of gears will depend also upon the accuracy of manufacture, material, heat treatment, mountings, type of lubricant, provision for heat dissipation and other factors.

In some of the elements of gear tooth design, there is no conflict between scoring resistance and bending strength. For example, in a pair of gears with a high ratio, scoring resistance can be improved by the use of long and short addendums. Such proportions may permit adequate tooth action and at the same time avoid contact in the region where contact stress and sliding velocity would be high.

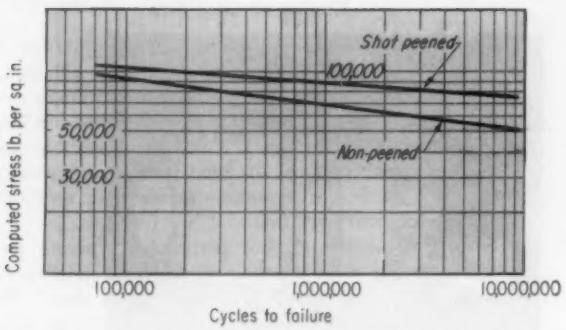
This procedure is also advantageous for bending strength because such proportions will normally result in a proportionately greater thickness of the pinion tooth, which will be required to undergo a greater number of stress cycles than the gear tooth.

This compatability does not occur in all of the elements of the design of the teeth. For example, a coarse pitch may be used where high bending strength is required, because of its advantage in a greater tooth thickness. However, this means greater tooth heights for an adequate number of teeth in contact and results in tooth action

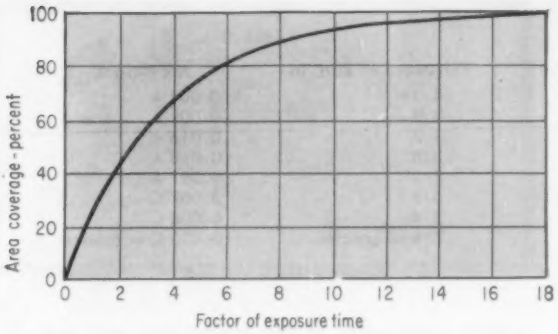
TABLE I—TYPES OF FAILURE IN GEARS

Gear tooth failure can be classified into three major types:

1. Bending failure, or tooth breakage. This is a fatigue type of failure caused by high bending stress in the root fillet. It is the most serious type because a broken tooth usually renders the gears inoperative.
2. Pitting. This is also a fatigue type of failure but occurs on the working profile of the tooth due to high contact stresses. It is not as serious as bending failure because although a moderate noise may develop after the initial stages, the gears can usually be run for an extended period before complete failure occurs.
3. Scoring. This is not a fatigue failure, and may occur early in the life of the gears. It is a welding of the tooth surfaces due to high contact stresses in combination with high sliding velocity. It is characterized by radial scratches on the profiles, somewhat similar to the seizing of a journal bearing.



1. **FATIGUE CHART** of carburized, automotive type spur and helical gears, shot peened and non-peened, and heat treated (60 Rc).



2. **RELATIONSHIP BETWEEN** area coverage and exposure time.

at a greater distance from the pitch point. Because it varies directly with this distance, the sliding velocity is greater, and there is the likelihood of high contact stresses.

Fatigue Strength Gain By Shot Peening

The above factors suggest a fine pitch for scoring resistance. But this would lead to low resistance to bending failure. Therefore, if the bending strength can be increased by shot peening it would permit the use of a finer pitch for greater scoring resistance.

For such data to be useful in design, it is necessary to consider the increase in allowable stress for a given life. For indefinitely long life, an increase of 50% or more in the endurance limit stress is not unusual. For shorter life requirements involving higher stresses, the gain in endurance limit stress is more moderate.

This is shown by Fig. 1. Each line on the chart represents the average life of a large number of gears. Note that the two lines diverge toward the right. For example, for an expected average life of 100,000 cycles the allowable stress is increased by approximately 10%. For a life requirement of 1,000,000 cycles the increase in allowable stress is somewhat more than 25%. For a life requirement of 10,000,000 cycles, the increase in allowable stress is almost 50%.

A specific example of the extent to which shot peening can be used to permit the designer to use a fine pitch is where shot peening permitted a change from 10 pitch to 14 pitch in production. The same center distance and face width were used and noise characteristics were improved.

Application of Shot Peening to Gears

As in other machine parts, shot peening of gears should be the last operation insofar as the highly stressed areas are concerned. Although the effect of the process is to impose a residual compressive stress on the surface by virtue of a lateral expansion of the surface layer, there is little if any change in the tooth profile, except for an increase in the surface roughness. Shot peening is effective in increasing fatigue strength of both hardened gears (60R_c) and gears of machinable hardness.

If it seems necessary to achieve a high degree of surface finish on the working profiles, this can be accomplished on gears of machinable hardness by shaving after peening. Gears of high hardness can be honed. Both of these procedures permit the profiles to be processed to the required finish without disturbing the peened surface at the roots of the teeth.

Control of Shot Peening

Control of the peening operation consists in a sense of appraising the blast itself. For this purpose standard Almen test strips and equipment have been standardized by the SAE. A thin strip of spring steel is fastened with screws to a solid block and passed through the blast, simulating the work. The lateral expansion of the surface results in a curvature of the test strip when it is removed from the block, the peened side being convex. The degree of curvature is then measured as arc height on a standard cordal distance. A thin strip "A" is used for light impact, and a thicker strip "C" is used for heavy impact. The arc height is designated in thousandths of an inch with the suffix "A" or "C" depending upon the strip used.

Specifications for a peening job are based on arc height and some measure of coverage. In establishing such specifications, the arc height should be in keeping with the thickness of the part in the location of maximum stress, as well as the overall requirement of a particular job. It is not practical to generalize on the ideal arc height for all applications because of the wide variation in requirements. Wherever possible, it is good practice to establish by fatigue tests the most effective arc height for a particular job in the light of the overall requirements. Table II is based on a large number of fatigue tests, and can be used as a guide in establishing appropriate arc height for a given thickness in the parts to be shot peened.

Having set up the specifications it is important, for best results at lowest cost, to obtain the required arc height with uniformly sized shot. Fatigue tests have indicated that, if a high percentage of undersized shot is permitted to accumulate in the peening machine, the expected fatigue strength may not be achieved, even though specified arc height is obtained. For this reason, a peening machine should be equipped with a separator capable of removing broken or undersized shot in continuous operation as soon as possible after it becomes smaller than the original size. Obviously, it is necessary to provide for

TABLE II

Thickness of Part, in.	Arc Height
1/16	0.004 A
1/8	0.008 A
1/4	0.014 A
3/8	0.018 A
1/2	0.021 A
5/8	0.007 C
3/4	0.008 C
7/8 or greater	0.010 C or greater

uniform replacement of the broken shot with new shot by means of an adding device.

Coverage in Shot Peening

Coverage in shot peening is related to the degree of exposure to the blast. It may be defined as the proportion of a given area of the work which has received impact of the peening blast.

In any peening operation with constant conditions, there is a definite relationship between coverage and exposure time, as shown in Fig. 2. The horizontal scale is relative and can be expressed in terms of time, or number of passes under given conditions.

Note that coverage approaches 100% as the exposure time is increased indefinitely. For this reason, it is convenient to refer to 98% as a finite measure of approximately "full coverage."

Fatigue Strength as Influenced by Coverage

Fatigue tests have indicated that, provided the arc height is not excessive for the thickness of the part, the fatigue strength increases with increased coverage. In many cases it increases gradually, even after the exposure time far exceeds that required to obtain 98%. This appears to be especially true in peening parts of irregular shape such as gear teeth. For example, gears peened with an exposure of three times the required to obtain 98% coverage give results well above the chart for peened gears in Fig. 1. This is referred to as a coverage of 3. Gears with a coverage of 6 to 8 show even greater increase.

It is important to specify a degree of coverage in accordance with the economics of the gears in question. For example, with gears involving a very high production rate, the cost of manufacturing the gears may be relatively small. In such a case, it might be economical to specify a coverage of 98%, or even less. The fatigue tests mentioned above have shown a more gradual increase in average life after a coverage of about 80% is obtained.

Reference to Fig. 2 will reveal that the exposure time required to obtain 80% coverage is less than half that required for 98%. Consequently the additional increase in fatigue strength at full coverage may, in some cases, not be warranted.

A coverage of 3 is not uncommon in high volume production of relatively low cost gears. There are applications in which the cost of manufacturing the gears is sufficiently high that the cost of short peening is insignificant, even though a coverage of 6 or 8 is specified. In this case, increase in fatigue strength can be had at negligible cost.

Choice of Shot Size

The size of shot best suited for a given application depends upon the arc height and coverage to be obtained.

For steel gears, a small shot at high velocity will result in about the same increase in fatigue strength as a larger shot at correspondingly lower velocity, provided the same arc height and coverage are used. However, whatever shot size is used, it is important to maintain uniformity of size for efficient operation.

Since the number of shot particles per pound varies inversely as the cube of their diameter, it follows that coverage is obtained much faster with small shot. This, of course, means that the shot velocity must be higher to obtain the same arc height. However, in spite of the fact that shot usage per hour increases considerably with shot velocity, the increased production compensates for it, so that the shot usage per part peened is about the same. The end result is that the most economical operation can be usually obtained by using the smallest uniformly sized shot with which the required arc height can be obtained.

Type of Shot

It has been demonstrated that it is not necessary that shot for peening gears with a hardness of 60 R_c have the same hardness as the work. Equally good results have been obtained by peening fully hardened work with cast steel shot (42-50 R_c) and with chilled iron shot (60 R_c). A good grade of cast steel shot has a far greater resistance to breakage and therefore is much more economical.

Cut wire shot can also be used if its hardness is sufficiently high and uniform. However, its use is usually limited to the larger sizes because of the increase in cost per pound as the size decreases.

Equipment for Shot Peening

To insure an adequate peening job, the work should pass through the blast in a mechanically controlled cycle, so that all critical areas will be uniformly covered.

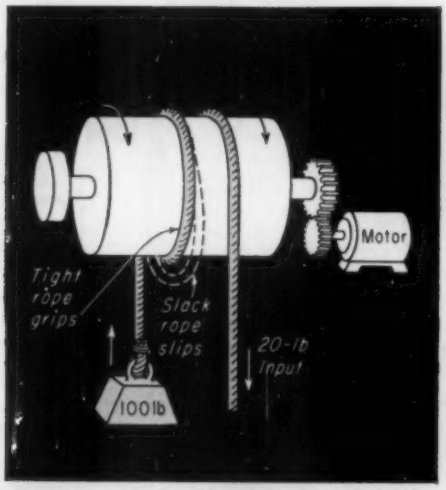
The equipment for accelerating shot is generally of two types—one which utilizes compressed air and the other a rotating bladed wheel. Air equipment may be of the induction type which accelerates the shot within the nozzle itself, or direct pressure type in which the shot is added to the air stream under pressure.

The induction nozzle is sometimes used in applications which require very few small parts to be peened. The direct pressure type is capable of throwing more shot at a higher velocity and therefore can be used in cases where more parts are required. In applications involving a reduction of cost by shot peening in design, the volume of production is usually such that the natural choice is the wheel type of equipment. This is because of the fact that the wheel type is capable of accelerating many times as much shot, to the same velocity, with an expenditure of a fraction of the horsepower required in the compressed air types.

REFERENCE:

Shot Peening in Relation to Gear Tooth Scoring by J. C. Straub, Wheelabrator Corporation, Mishawaka, Indiana. Published in *Lubrication Engineering*, March 1959, pp 106-109.

From: Control Engineering



Capstan principle (above) is basis for mechanical power amplifier (below) that combines two counterrotating drums. Drums are continuously rotating but only transmit torque when input shaft is rotated to tighten band on drum A. Overrun of output is stopped by drum B, when overrun tightens band on this drum.

6 APPLICATIONS FOR THE CAPSTAN-TYPE POWER AMPLIFIER

Precise positioning and movement of heavy loads are two basic jobs for this all-mechanical torque booster.

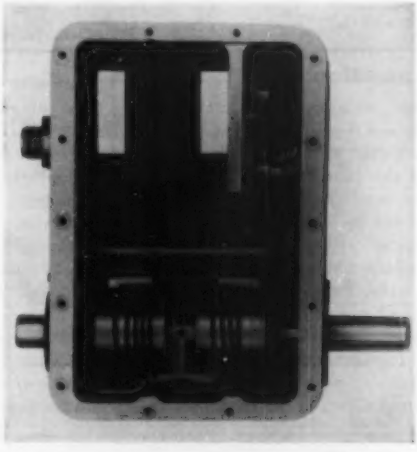
L. A. ZAHORSKY
Universal Match Co.

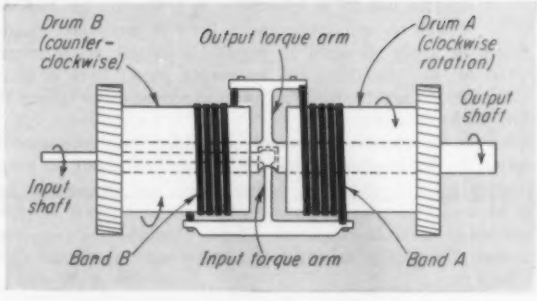
This mechanical power amplifier has a fast response. Power from its continuously rotating drums is instantaneously available. When used for position-control applications, such methods as pneumatic, hydraulic, and electrical systems—even with continuously running power sources—require transducers of some kind to change signals from one energy form to another. The mechanical power amplifier, on the other hand, permits direct sensing of the controlled motion.

Four major advantages of this all-mechanical device are:

1. Kinetic energy of the power source is continuously available for rapid response.
2. Motion can be duplicated and power amplified without converting energy forms.
3. Position and rate feedback are inherent design characteristics.
4. Zero slip between input and output eliminates the possibility of cumulative error.

One other important advantage is the ease with which this device can be adapted to perform special functions—jobs for which other types of systems would require the addition of more costly and perhaps less reliable components. The six applications which follow illustrate how these advantages have been put to work in solving widely divergent problems.



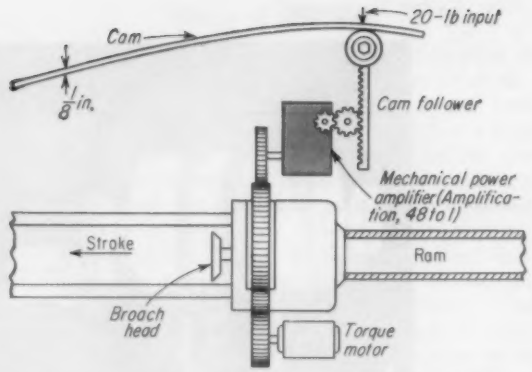


E POWER TRANSMISSION

1. Nonlinear broaching

Problem: In broaching large bore rifles, the twist given to the lands and grooves represent a nonlinear function of barrel length. Development work on such rifles usually requires some experimentation with this function. At present, rotation of the broaching head is performed by a purely mechanical arrangement consisting of a long heavy wedge-type cam and appropriate gearing. For steep twist angles, however, the forces acting on this mechanism becomes extremely high.

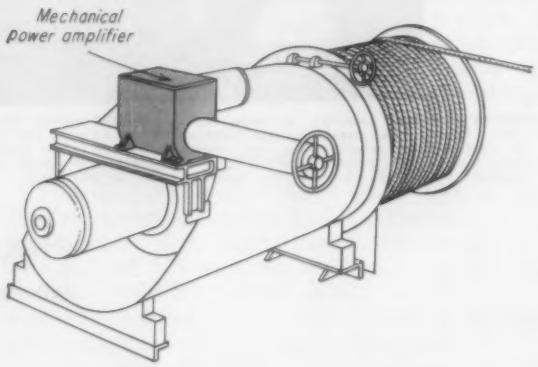
Solution: A suitable mechanical power amplifier, with its inherent position feedback, was added to the existing mechanical arrangement, as shown in sketch. The cam and follower, instead of having to drive the broaching head, simply furnish enough torque to position the input shaft of the amplifier.



2. Hydraulic winch control

Problem: Hydraulic pump-motor systems represent an excellent method of controlling position and motion at high power levels. In the 10- to 150-hp range, for example, the usual approach is to vary the output of a positive displacement pump in a closed-loop hydraulic circuit. In many of the systems that might be used to control this displacement, however, a force feedback proportional to system pressure can lead to serious errors or even oscillations.

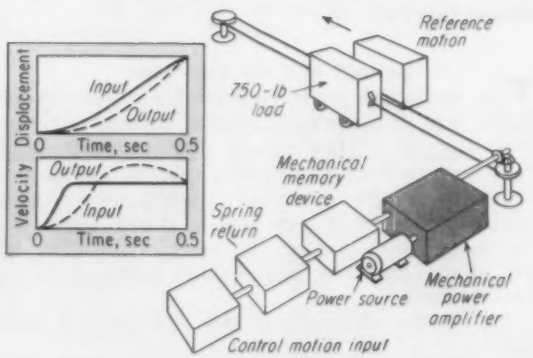
Solution: Sketch shows an external view of the complete package. The output shaft of the mechanical power amplifier controls pump displacement, while its input is controlled by hand. In a more recent development, requiring remote manual control, a servomotor replaces this local handwheel. Approximately 10 lb-in. torque drives a 600 lb-in. load. If this system had to transmit 600 lb-in. the equipment would be more expensive and more dangerous.



3. Load positioning

Problem: It was necessary for a 750-lb load to be accelerated from standstill in 0.5 sec and brought into speed and position synchronization with a reference linear motion. It was also necessary that the source of control motion be permitted to accelerate more rapidly than the load itself. Torque applied to the load could not be limited by means of a slipping device.

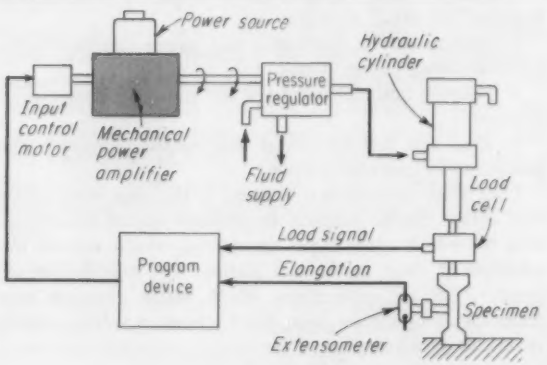
Solution: A system using a single mechanical power amplifier provided the solution, sketch. Here a mechanical memory device preloaded for either rotation is used to drive the input shaft of the amplifier. This permits the input source to accelerate as rapidly as desired. Total control input travel minus the input travel of the amplifier shaft is temporarily stored. After 0.5 sec the load reaches proper speed, and the memory device transmits position information in exact synchronization with the input.

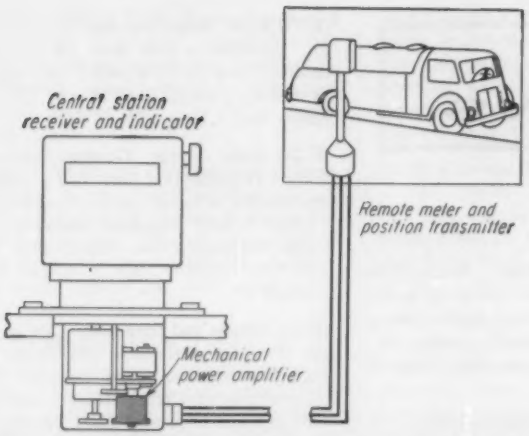


4. Tensile testing machine

Problem: On a hydraulic tensile testing machine, stroke of the power cylinder had to be controlled as a function of two variables: tension in, and extension of, the test specimen. A programming device designed to provide a control signal proportional to these variables, had an output power level of about 0.001 hp—too low to drive the pressure regulator controlling the flow to the cylinder.

Solution: An analysis of the problem revealed three requirements: output of the programmer had to be amplified about 60 times, position accuracy had to be within 2 deg, and acceleration had to be held at a very low value. A mechanical power amplifier satisfied all three requirements. Sketch illustrates the completed system. Its design is based principally on steady-state characteristics.





5. Remote metering & counting

Problem: For a remote liquid metering job, synchro systems had been used to transmit remote meter readings to a central station and repeat this information on local indicating counters. The operation involved a large number of meters and indicators. As new devices were added (ticket printers, for instance), the torque requirement also grew.

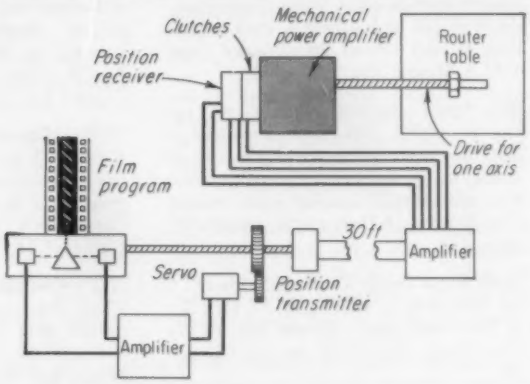
Solution: Use of mechanical power amplifiers in the central station indicators not only supplied extra output torque but also made it possible to use synchros even smaller than those originally selected to drive the indicators alone.

The synchro transmitters currently used operate at a maximum speed of 600 rpm and produce only about 3 oz-in. of torque. The mechanical power amplifiers furnish up to 100 lb-in. and are designed to fit in the bottom of the registers as shown in sketch. Total accuracy is within 0.25 gallon, error is noncumulative.

6. Irregular routing

Problem: To remotely control the table position of a routing machine from information stored on a film strip. The servoloop developed to interpret this information produced only about 1 oz-in. of torque. About 20 lb-ft was required at the table feedscrew.

Solution: Sketch shows how a mechanical power amplifier supplied the necessary torque at the remote table location. A position transmitter converts the rotary motion output of the servoloop to a proportional electrical signal and sends it to a differential amplifier at the machine location. A position receiver, geared to the output shaft, provides a signal proportional to table position. The differential amplifier compares these, amplifies the difference, and sends a signal to either counterrotating electromagnetic clutch, which drives the input shaft of the mechanical power amplifier.



OPERATING DATA FOR MECHANICAL POWER AMPLIFIERS

APPLICATION PARAMETERS		RIFLE BROACH	ROUTER		ACCELERATION SPEED AND POSITION CONTROL		HYDRAULIC WINCH CONTROL	TENSILE TESTER	REMOTE METERING
			SYSTEM	MPA	SYSTEM	MPA			
INPUT TORQUE LB. IN.		75	0.75	2	20+	2–6	5	0.1	0.75
OUTPUT TORQUE LB. IN.		3600	230	230	—	240	600	5	6.25
AMPLIFICATION		48	308	115	—	40	120	50	8.13
NORMAL RPM		—	—	—	50	50	0	50	200
MAXIMUM RPM		INPUT 108 OUTPUT 18	950	190	INF.	50	100	96	200
NUMBER OF REVERSALS PER MINUTE		—	1100	1100	120	120	20	—	—
STROKE FOR ABOVE REVERSALS		—	335°	67°	—	—	720°	2880°	—
ERRORS PERMITTED	MPA	BROACH							
BACKLASH	2°	0°	—	1.5°	—	1.5°	2°	2°	6°
PROPORTIONAL AT FULL LOAD	1°	0.009°	—	1.0°	—	1.0°	10°	1°	3°

REFERENCE:

Mechanical Power Amplifier Boosts Torque, Transmits Position by L. A. Zahorsky, Manager, Components Engineering, Universal Match Co, St. Louis, Missouri. Published in Control Engineering, Feb '60, p. 80.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(E-1) Ball Screws, Splines and Ways—Catalog, 8 pp. Graphs and tables show dimensions, load, torque and speed ratings. Also load-life factors. Beaver Precision Products, Inc, 651 N Rochester Rd, Clawson, Mich.

(E-2) Clutches and Converters—Bulletin, 84 pp. Provides plans, specifications, maintenance instructions. Clutches have capacities from 105 to 500 lb-ft in truck service. Borg & Beck Div of Borg-Warner Corp, 6558 S Menard Ave, Chicago 38.

(E-3) Speed Reducers—Catalog, 48 pp. Provides ratings, ratios and dimensions of shaft mounted reducers, variable speed belt drives, motor and reducer combinations. Also stainless steel universal joints. Boston Gear Works, 14 Hayward St, Quincy 71, Mass.

(E-4) Right Angle Gearing—Brochure, 4 pp. Describes skew axis gear sets for 1.5:1 to 10:1 ratio range. Spiroid Div, Illinois Tool Works, 2501 N Keeler Ave, Chicago 39.

(E-5) Universal Joints—Catalog, 9 pp. Shows construction, ratings, sizes from ⅜ to 6 in. OD. Explains selection. Curtis Universal Joint, Inc, 4 Birnie Ave, Springfield, Mass.

(E-6) Worm Gear Sets—Bulletin, 23 pp. Provides complete dimensions, ratios, ratings, tooth data, general discussion of subject. Ratios to 70:1. De Laval Steam Turbine Co, 200 Nottingham Way, Trenton 2, NJ.

(E-7) Speed Reducers—Bulletin, 64 pp. Provides construction details, dimensions, installation data and selection tables for shaft mounted, flange mounted, right angle and screw conveyor drive types. Dodge Mfg Corp, S Union St, Mishawaka, Ind.

(E-8) Rotary Actuators—Catalog, 20 pp. Oscillating hydraulic actuator indexes, mixes, transfers. Design for these and other functions explained. Gives dimensions and ratings. Ex-Cello-O Corp, 945 E Sater St, Greenville, Ohio.

(E-9) Clutches and Transmissions—Catalogs, 8 pp. Offers installation diagrams, dimensions, curves and charts for matching to small gasoline engines. Fairbanks, Morse & Co, Magneto & Engine Accessories Div, Beloit, Wisc.

(E-10) Magnetic Clutches, Brakes—Bulletin, 4 pp. Gives sizes, ratings of multidisc brakes and clutches. Brakes spring or power engaged. Fawick Airflex Div, Fawick Corp, 9919 Clinton Rd, Cleveland 11.

(E-11) Clutches and Brakes—Bulletin, 33 pp. Describes clutches, brakes, couplings, accessories and their use in industrial machinery, construction equipment. Many operated by air expanded flexible tube. Fawick Airflex Div, Fawick Corp, 9919 Clinton Rd, Cleveland 11.

(E-12) Magnetic Clutches and Brakes—Bulletin, 8 pp. Presents design, application and operating data on models rated from 36 to 48,000 in.-lbs. Fawick Airflex Div, Fawick Corp, 9919 Clinton Rd, Cleveland 11.

(E-13) Overrunning Clutches—Brochure, 12 pp. Describes sprag type clutches which provide drive and overrunning in one or two directions. Formsprag Co, 23601 Hoover Rd, Warren, Mich.

(E-14) Reversing Clutch—Bulletin, 6 pp. Shows construction, specifications of torque converter - clutch - transmission package which has a capacity of 200 ft-lbs at 2500 rpm. Funk Mfg Co, Box 577, Coffeyville, Kans.

(E-15) Transmissions—Catalog, 40 pp. Provides ratios, ratings, dimensions of modular units that can be combined as needed. Funk Mfg Co, Box 577, Coffeyville, Kans.

(E-16) V-belts—Catalog, 33 pp. Provides tables, graphs and instructions for designing a drive using belts and sheaves shown. The Gates Rubber Co, 999 S Broadway, Denver, Col.

(E-17) Roller Bearings—Catalog, 67 pp. Provides sizes and ratings for cylindrical solid and wound roller, solid and split race bearings. Hyatt Bearing Div, General Motors Corp, Harrison, NJ.

(E-18) Mitre Gear Units—Bulletin, 6 pp. Provides mounting dimensions, capacities, suggested applications for right angle power transfer units rated from ¼ to 2 hp. Crown Gear, Div of Harrington & Richardson, Inc, 320 Park Ave, Worcester, Mass.

(E-19) Right Angle Gearing—Brochure, 8 pp. Describes a gear form for light to medium loads in 3:1 to 400:1 ratio range. Spiroid Div, Illinois Tool Works, 2501 N Keeler Ave, Chicago 39.

(E-20) Right Angle Gearing—Brochure, 36 pp. Describes gear form used in similar applications as worm gears. Designed for backlash control, production economy, precision and high ratios. Spiroid Div, Illinois Tool Works, 2501 N Keeler Ave, Chicago 39.

(E-21) Chains and Sprockets—Catalog, 44 pp. Provides dimensions and ratings of single and multiple strand, conveyor, leaf roller chain, sprockets, flexible couplings. Link-Belt Co, Prudential Plaza, Chicago 1.

(E-22) Compound Variable Speed Drives—Catalog, 4 pp. Illustrates, tabulates specifications for several v-belt drive systems. Speed Selector Inc, Box 312, Chagrin Falls, Ohio.

(E-23) Speed Reducers—Bulletin, 20 pp. Provides hp ratings, torque ratings, dimensions for double reduction worm reducers with ratios up to 4900 to 1. Cone-drive Gears, Div of Mich Tool Co, 7171 E McNichols Rd, Detroit 12.

(E-24) Power Transmission—Catalog, 136 pp. Provides full specifications, dimensions and ratings for chain drives, clutches, couplings, speed reducers and others. Morse Chain Co, Div of Borg-Warner, S Aurora St, Ithaca, NY.

(E-25) Idler Pulleys—Bulletin, 4 pp. Gives dimensions and capacities of pulleys with sealed ball bearings. New Departure Div, General Motors Corp, 269 N Main St, Bristol, Conn.

(E-26) Variable Speed Drive—Brochure, 16 pp. Output from motor-generator drives dc motor. Drives range from 1 to 350 hp Reliance Electric & Engineering Co, 24701 Euclid Ave, Cleveland 17.

(E-27) Ball Bearing Screws and Splines—Catalog, 24 pp. Provides ratings, dimensions, construction details, discussion and curves of design factors. Saginaw Steering Gear Div, General Motors Corp, 3900 Holland Rd, Saginaw, Mich.

(E-28) Gear Couplings—Catalog, 19 pp. Shows construction, dimensions and specifications for all-steel couplings with ratings to 4000 hp at 100 rpm. Sier-Bath Gear & Pump Co, 9211-A Hudson Blvd, N Bergen, NJ.

(E-29) Gear Couplings—Brochure, 4 pp. Describes flexible couplings with nylon sleeves for speeds up to 5000 rpm. Sier-Bath Pump & Gear Co, Inc, 9211-A Hudson Blvd, N Bergen, NJ.

(E-30) Variable Pitch Sheaves—Catalog, 8 pp. Wide speed-range, standard v-belt sheave combinations shown. Includes specifications, speed ratios, hp capacities. Speed Selector Inc, Box 312, Chagrin Falls, Ohio.

(E-31) Automatic Clutches and Brakes—Catalog, 4 pp. Gives specifications and tables for matching clutches to motors and gasoline engines. Mercury or mechanical actuation. Mercury Clutch Div, Automatic Steel Products, Inc, 1201 Camden Ave SW, Canton, Ohio.

(E-32) Flexible Shafts—Catalog, 8 pp. Provides dimensioned drawings, tables of ratings for over 180 configurations. Includes ordering information and design criteria. F W Stewart Corp, 4311 Ravenswood Ave, Chicago.

(E-33) Torque Converters—Bulletin, 14 pp. Provides dimensions and horsepower ratings of different sizes. Converters are built with a single-stage oil turbine. Torque rating of the largest converter is 650 lb-ft. Twin Disc Clutch Co, 1328 Racine St, Racine, Wisc.

(E-34) Speed Reducers—Catalog, 92 pp. Presents illustrations, ratings of worm and spur gear reducers, gears and flexible couplings. Abart Gear & Machine Co, 4834-36 W 16 St, Chicago 50.

(E-35) Flexible Couplings—Catalog, 12 pp. Lists sizes and ratings of rubber-cushioned, sleeve bearing flexible couplings for direct-connected machines. Variations include brake drum coupling, others. Ajax Flexible Coupling Co, Inc, 104 Portage Rd, Westfield, NY.

(E-36) Dihedral Gear Couplings—Catalog, 8 pp. Self-aligning couplings handle angular and offset drives with standard, floating shaft and spindle drives. Ajax Flexible Coupling Co, Inc, 104 Portage Rd, Westfield, NY.

(E-37) Flexible Couplings—Bulletin, 4 pp. Provides illustrations, tables of dimensions and load capacities for couplings with rubber cushioned sleeve bearings and dihedral gears. Ajax Flexible Coupling Co, Inc, Westfield, NY.

(E-38) V-Belts—Catalog, 64 pp. Offers extensive data and design information such as hp rating, speed tables, cross-sections, speed ratios for many configurations. Includes prices. American Biltrite Rubber Co, Boston Woven Hose & Rubber Div, 29 Hampshire St, Cambridge, Mass.

(E-39) Speed Reducers—Catalog, 28 pp. Presents ratings of flanged and motorized worm gear speed reducers. American Stock Gear Div, Perfection Gear Co, 152 St & Vincennes Rd, Harvey, Ill.

(E-40) Gears—Catalog, 232 pp. Contains tables of dimensions and specifications for spur gears, change gears, worms, sprockets, universal joints and other stock items. American Stock Gear Div, Perfection Gear Co, 152 St & Vincennes Rd, Harvey, Ill.

(E-41) One-way Torque Device—Brochure, 4 pp. Device combines bearings and couplings, allows only driving shaft to transmit torque. Ratings to 26,000 in.-lbs. Ann Arbor Bearing & Mfg Co, 817 Wildt St, Ann Arbor, Mich.

(E-42) Universal Joints—Catalog, 28 pp. Presents specifications and dimensions for covered and uncovered universal joints and assemblies for industrial, aircraft and ordnance applications. The Apex Machine & Tool Co, 1025 S Patterson Blvd, Dayton 2, Ohio.

(E-43) Precision Gears—Catalog, 260 pp. Provides data tables for solid and anti-backlash spur gears with diametral pitches from 32 to 120. Also standards, terminology, shafting, precision ball bearings. Atlas Precision Products Co, 3801 Caster Ave, Philadelphia 24.

(E-44) Fine Pitch Gears—Brochure 4 pp. Tabulates gear tooth data and illustrates many types available. Beaver Gear Works, Inc, 1025 Parmele St, Rockford, Ill.

(E-45) Centralized Lubrication—Bulletin, 4 pp. System consists of central pump, filter and reservoir from which oil is sent to bearings through individual meters. Bijur Lubricating Corp, Rochelle Park, NJ.

(E-46) Gears and Couplings—Catalog, 80 pp. Presents ratings, dimensions of gears, speed reducers, sprockets, chain, flexible couplings, universal joints, pillow blocks. Includes design guides to aid selection. Charles Bond Co, 617-623 Arch St, Philadelphia.

(E-47) Universal Joints—Brochure, 4 pp. Furnishes illustrations, parts lists, tables of dimensions and load capacities. Borgeson Mfg Co, Inc, 38 Monroe St, Torrington, Conn.

(E-48) Speed Reducers—Catalog, 28 pp. Provides hp and torque ratings, efficiency graph, dimensional tables and selection guide for worm reducers and complete motorized drives. David Brown, Inc, 999 Beeches St, San Leandro, Cal.

(E-49) Spring Clutches—Catalog, 30 pp. Explains operation, construction, application of clutches which work by gripping action of a coil spring. Gives specific data on on-off, over-running and back-stopping, indexing and other types. Curtiss-Wright Corp, Marquette Div, 1145 Galewood Dr, Cleveland 10.

(E-50) Flexible Couplings—Brochure, 6 pp. Provides dimensions, ratings, prices and descriptions. William J Browne, 320 Broadway, NYC 7.

(E-51) Notched Belt Drives—Catalog, 56 pp. Provides tables of speed ratios, capacities, dimensions and design guides for notched belts and pulleys. Browning Mfg Co, Maysville, Ky.

(E-52) Electro-mechanical Clutches and Brakes—Bulletin, 4 pp. Size range fits servomechanisms, computers, automation equipment. Smallest capacity is 2½ in.-oz torque. Carmody Corp, 2360 Wehrle Dr, Buffalo 21.

(E-53) Gears and Sprockets—Catalog, 140 pp. Also includes: Couplings, hand wheels, pillow blocks, pulleys, speed reducers, bushings, bearings, roller chain and others. Chicago Gear Works, 440-450 N Oakley Blvd, Chicago 12.

(E-54) Speed Reducers—Bulletin, 24 pp. Presents dimensions, rating, construction of fan cooled worm gear reducers. Cleveland Worm & Gear Div, Eaton Mfg Co, 3249 E 80 St, Cleveland, Ohio.

(E-55) Variable Speed Drive—Bulletin, 8 pp. Mechanical, in-line drive gives ratios from 3:1 to 1:3. Ratings and dimensions are shown. Cleveland Worm & Gear Div, Eaton Mfg Co, 3300 E 80 St, Cleveland 4.

(E-56) Silicone Lubricants—Brochure, 8 pp. Compares silicone oils and greases to organic lubricants. Dow Corning Corp, Midland, Mich.

(E-57) Heavy Duty Transmissions—Brochure, 8 pp. Shows standard single-speed transmissions rated to take up to 2400 ft-lbs input torque. Includes some multi-speed custom models. Cotta Transmission Co, 2340 11 St, Rockford, Ill.

(E-58) Gears—Brochure, 6 pp. Illustrates facilities for making small and medium size gears. Charles E Crofoot Corp, Central St, S Easton, Mass.

(E-59) Worm Gear Reducers—Catalog, 30 pp. Provides notes on selection, power tables, efficiency graphs for fan cooled units to 250 hp. Crofts U S A Inc, 2542 W Peterson Ave, Chicago 45.

(E-60) Couplings—Catalog, 4 pp. Gives tables of specifications and dimensions of flexible and shear types. Includes guide for selecting. Brown Engineering Co, 108 N Third St, Reading, Pa.

(E-61) Ribbed V-belts—Brochure, 4 pp. Shows belt horsepower ratings and dimensions of belt cross-sections. Dayton Industrial Products Co, 2001 Janice Ave, Melrose Park, Ill.

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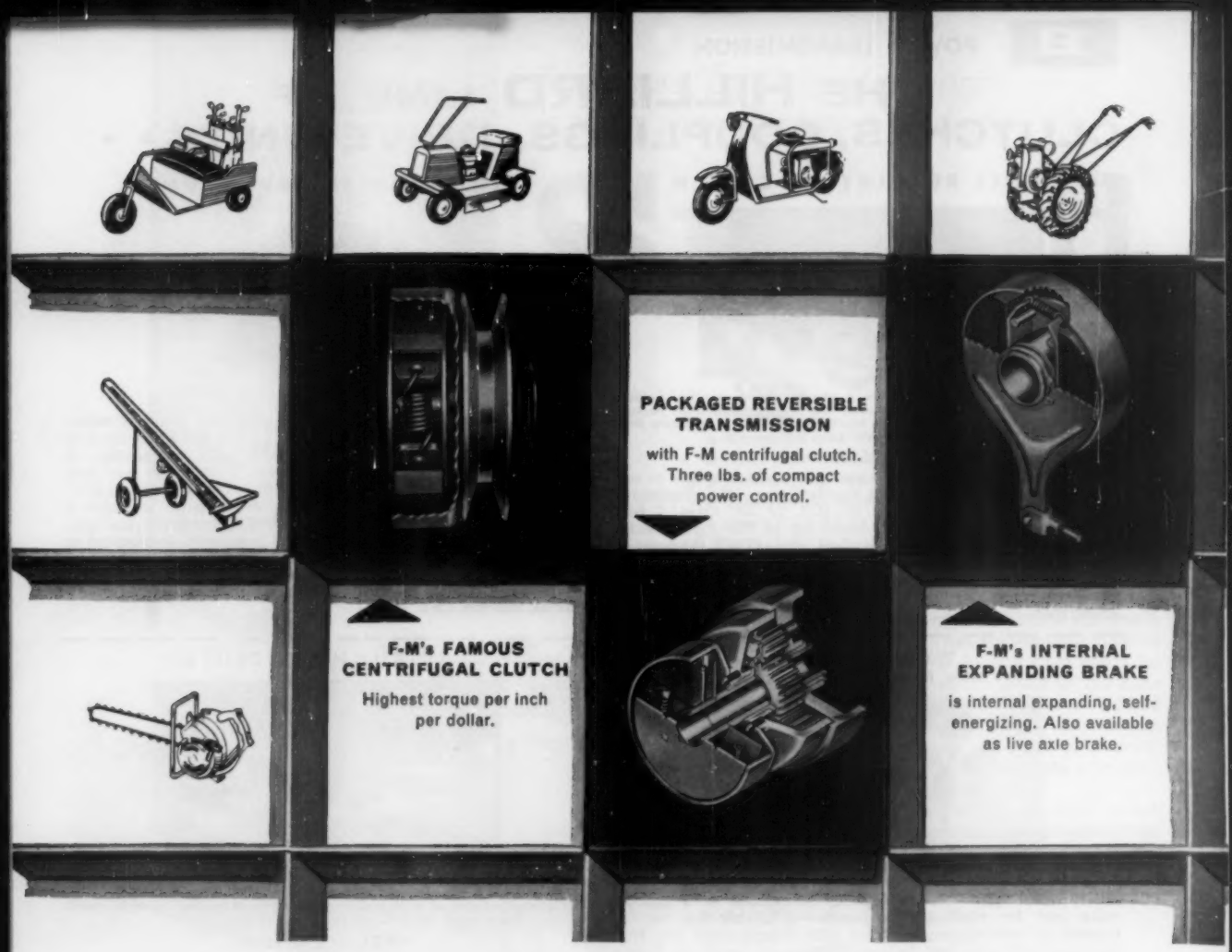
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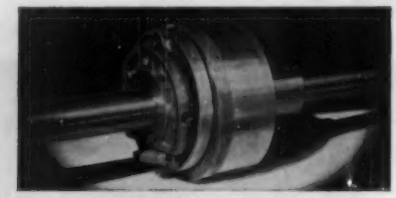

USE. Rivet machines, snap fastener machines, shears, staplers, bottling machinery, cut-off mechanisms, indexing and feeding equipment, packaging processes or wherever controlled intermittent motion is necessary from a continuously rotating source of power.

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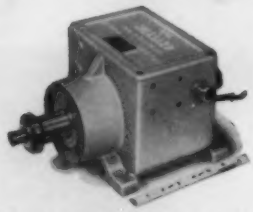
Made in 2 types in 11 standard sizes plus special designs to suit particular applications. Smallest standard size—1¼" diameter x 1 13/32" shaft length. ¼" bore, .04 H.P. @ 100 r.p.m. 2 foot pounds torque normal rating. Speed up to 850 r.p.m. under certain conditions. Largest standard size—17½" diameter x 17⅝" shaft length, bore up to 4 15/16", 176 H.P. @ 100 r.p.m., 9240 foot pounds torque normal rating. Approximate maximum speed 65 r.p.m. Write for Bulletin 239 for further detailed information.

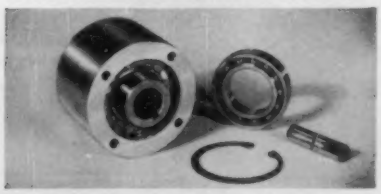
INTERMITTENT DRIVE UNIT



Hilliard's complete, single package unit that converts rotary power to precise intermittent motion . . . clip and bend, shear or slash, oscillate or repeat, raise or lower, index and position. It can be installed on existing equipment, designed into new machinery and reused after production line changes. I.D.U. eliminates the need of buying separate parts to assemble a "custom" machine with assorted mechanisms to apply and control it. Features highly flexible control — manual, mechanical or electrical — permitting "demand" type operations in fixed or variable cycles. A protected drive, totally enclosed in an oil bath housing, it is ideal for dusty, "steamed" or "wash-down" conditions. Bulletin. I.D.U. 2

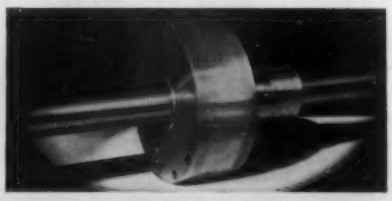
WEDGE-ROLL

THE NEW OVER-RUNNING CLUTCH



A new improved type of clutch designed for specific application where great torque capacity is needed in a limited space and for high speed operation. Has all the regular features of over-running clutches plus exceptionally low free wheeling resistance and balanced design to result in longer service life. The Wedge-Roll Clutch cannot jam or lock in reverse even after long wear. There are four clutch sizes ranging from 3½" to 7⅛" diameter and from 1.8 to 36 H.P. at 100 RPM. Additional sizes, both larger and smaller, are available on special order. Ask for the Wedge-Roll Bulletin.

OVER-RUNNING CLUTCH



USE: Dual drive, two speed drive or standby drive on boiler stokers, blowers, induced or forced draft fans, dry cleaning machines, ventilating fans and similar equipment.
Also for ratchet feed on presses or automatic back-stop on conveyors or to permit free rotation when the driver slows or stops.

SPECIFICATIONS

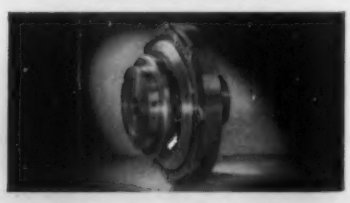
Made in 7 types and 15 standard sizes plus special designs for specific installations. Smallest standard size—1 13/16" diameter x 1 25/64" shaft length. ⅜" bore, 1/20 H.P. @ 100 r.p.m., 31.5 inch pounds torque normal rating. Largest standard size—25" diameter x 16⅞" shaft length 7 15/16" maximum bore, 394 H.P @100 r.p.m. 20694 foot pounds torque normal rating. Ask for Bulletin 231 for comprehensive data.

CENTRIFUGAL

AUTOMATIC CENTRIFUGAL CLUTCH COUPLING

Improves starting conditions and provides smooth acceleration on drives for high inertia equipment; prevents excessive torque transmission during starting of textile machinery; prevents torsional resonance on internal combustion engine drives; provides automatic coupling on emergency and dual drive systems; provides overload protection and has exceptional ability to compensate for all types of misalignment. Operating mechanism requires no lubrication. Write for Bulletin CE-3 for additional information.

SLIP CLUTCH



USE: to protect speed reducers or gear trains against destructive overload, to reduce shock in door opening and closing mechanisms, as a safety feature where a machine is subject to jamming or to limit the torque of any drive.
Also to provide constant tension with varying speed as in a reeling or winding application.

SPECIFICATIONS

Made in 15 types and 11 sizes. The torque transmission of all slip units is adjustable and some models can be adjusted while in operation. Smallest clutch (light series)—2⅜" diameter x 1¾" shaft length, ½" or ⅝" bore, 9 foot pounds torque maximum capacity. Smallest clutch (regular series) 5¾" diameter x 4¾" shaft length, ¾", 1" or 1¼" bore, 38 foot pounds torque capacity. Largest clutch—27" diameter x 31⅜" shaft length, bore up to 8" 24600 foot pounds torque capacity. For complete description, request a copy for Bulletin 300.

• HILLIARD CLUTCHES AND COUPLINGS ARE EXCELLENT FOR ALL CLASSES OF INDUSTRIAL MACHINERY

All Products of THE HILLIARD CORPORATION ELMIRA, NEW YORK

CIRCLE 221 ON READER SERVICE CARD →

To assure product superiority leading manufacturers specify

Spiroid® gears

- **increased efficiency**
- **more power in less space**
- **positive backlash control**
- **exceptional accuracy**
- **ratios from 9:1 to 300:1**

These are only a few of the hundreds of proved applications utilizing the unique design and performance advantages of Spiroid gears. You may choose Spiroid gears in nylon, compacted metals, die-cast aluminum, bronze or hardened steel. They are available in ratios from 9:1 to 300:1 and range in size from gears for compact portable can openers to gears for the huge screw jacks in the world's largest wind tunnel. Spiroid gears cost from as little as 35¢ a set to as much as $4000 a set depending on their size, material, strength and accuracy requirements; each serves a specific need as economically as possible.

To get the full story of Spiroid gear strength, shock resistance, space and weight savings as well as their manufacturing and assembly versatility, send for your free file, "Low cost design begins with Spiroid's family of modern gears." Booklets on Planoid® and Helicon® gears will be included.

On-the-job proof at BLACK & DECKER

Spiroid gears are used in the Black & Decker "Shorty" electric drill to deliver the desired right angle drive at a ratio and size not practical with bevel gears. Excessive heat generation, a problem of worm gears, is eliminated by the use of Spiroid gears. The unique "Shorty" permits drilling holes in confined spaces. It is lightweight, small, easy to use . . . an excellent tool for electrical installations.

On-the-job proof at KEARNEY & TRECKER

Spiroid gears are used to rotate each of the three lead screws controlling the axes of the Kearney and Trecker "Milwaukee-matic", an automatic, tape controlled unit that can drill, bore and mill. Spiroid gears were selected because they can handle the required heavy torques at near zero backlash—a must for machine repeatability.

On-the-job proof at NATIONAL CASH REGISTER

Economical, space-saving Spiroid gears are used by the National Cash Register Company in their Class 61 model to permit the use of a slightly larger induction drive motor to gain the benefit of service-free performance. Spiroid gears replaced a set of worm gears permitting the more dependable power source with no increase in overall cash register size. The Spiroid pinion is rolled on the end of the motor shaft.

On-the-job proof at WEBCOR, INC.

Webcor, Inc., in a classified Government project, uses Spiroid gears for a unique tuning drive. No other system can provide the combined efficiency and high ratio required in a single gear set. Spiroid gears eliminated a complex series of spur and bevel gears previously used. Note particularly Webcor's interesting use of spur gear teeth on the O.D. of the Spiroid gears providing two gear functions with a single part.

Spiroid® gears

SPIROID DIVISION OF ILLINOIS TOOL WORKS

2501 North Keeler Avenue, Chicago 39, Ill.

TRANSMISSION BELTS from the Power Unlimited complete belt line

POWER UNLIMITED...

U. S. Rubber's research, development and manufacturing facilities all combine to produce Endless Transmission Belts that fulfill every Power Transmission need. For example:

U.S. *PowerGrip* "TIMING" BELT

These belts, invented by "U.S." research and manufactured by the "U.S." unparalleled facilities (in the only plant in the industry devoted exclusively to the production of endless transmission belts), are patented products. They were acclaimed by the Franklin Institute of Philadelphia the greatest power transmission belt invented in this decade.

PowerGrip "Timing"® Belts never stretch. They require no lubricating or maintenance. Operating without tension, they prolong the life of bearings. They are used on drives from fleapower to 1,000 hp. Speeds are from imperceptible to the eye and up to 16,000 f.p.m.

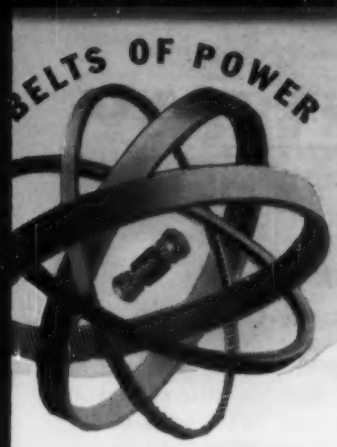
U.S. ROYAL V-BELTS

U.S. Royal V-Belts, with 40% greater h.p., are made by entirely advanced automation and curing processes.

They are without question unequalled for service on multiple transmission drives. Their *length-stability* makes this an undisputed fact. This has been proven in actual plant use in all parts of the country—on the West Coast (Ranchers Cotton Oil Co., Fresno, Calif.), the East Coast (The Ruberoid Co., Gloucester City, N. J.) and in a New England paper-making plant, to point out a few. Any U.S. Royal V-Belt will continue to pull its full share of the load long after one or more of the belts on an ordinary set have given up.

The length-stability of U.S. Royal V-Belts saves you dollars in Time and dollars in INVENTORY.

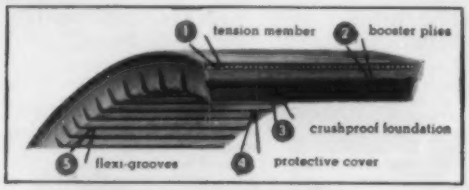
CIRCLE 222 ON READER SERVICE CARD



the only complete line of Transmission Belts

PRESS-CURED V-BELTS

The U. S. Royal line, of course, includes sizes larger than 180". These giant size V-belts are built by a new "U. S." process that practically eliminates length variation and greatly reduces belt matching problems.



VARIABLE SPEED BELTS

This Belt is non-squash, non-sag. This is the belt to do away with Variable Speed Belt problems. Hard, rigid rubber encloses soft rubber containing tension members. The *exclusive* and complete rigidity in these belts prevents squashing.

In plant after plant, users find that lengthwise stretch is just about non-existent. *No sagging.* This belt has complete accuracy regardless of speed changes—whether you switch from 2,000 rpm to 10.

U.S. ROYAL SPEEDAGE KORD ENDLESS BELTS

The U. S. Speedage Kord® Endless Belts are for really high-speed service—up to 18,000 f.p.m. Thin enough to operate over pulleys as small as ½" in diameter. Designed for work on open, serpentine and reverse drives. No seams, splices or laps to cause vibration. Available from stock in a wide range of popular sizes.

SPINNER BELTS

This belt will travel up to 113 mph with no vibration, *no noise*. The reduction in the length of modern spinning machines requires a belt of this high speed. Special "U. S." construction methods make possible building of belt with a minimum of splices, regardless of length. Contamination of yarn is prevented by another unique feature: no rubber on outside surfaces. The belt for uniform twist and smooth spindle operation.

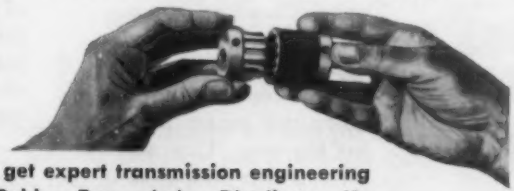
U.S. ROYAL FLAT BELTS

U. S. Spinner Belts are only one type of belt in the U. S. Complete Flat Belt line. "U. S." produces a variety of belts for a multiplicity of services. They each feature a specially woven duck for top strength and tenacity with top-quality friction between plies.

U.S. FLEXIBLE COUPLINGS

Misalignment, whether angular, axial or lateral, is compensated for by this coupling, most versatile ever produced. It provides torsional resilience by angular displacement and insulates both vibrationally and electronically (no metal-to-metal contact).

Design of this coupling is so free of complicated parts that cost is truly low in comparison with other couplings. It will pay you to insist on having these tried on your machinery. The result will be a very desirable reduction in maintenance costs.



The one and only sure way to get expert transmission engineering service is through your U. S. Rubber Transmission Distributor. He stocks the *only complete* transmission belt line. He never attempts to make one type of belt perform where another type should be used. He is unbiased in seeing that you get the right belt for your needs.

Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

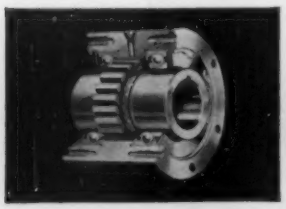
FORMSPRAG
OVER-RUNNING
CLUTCHES

For Greatest Torque, Precision and Life

The Formsprag clutch consists of a full complement of shaped sprags located between two concentric races. Full torque is transmitted from one race to the other by the wedging action of these precision sprags—there is no lost motion or slipping. Also, the sprags engage at constantly changing contact points—clutch life is lengthened and backlash eliminated. With greater contact in a given annular space, Formsprag clutches transmit more torque in relation to size and weight. Clutch-couplings utilizing Formsprag ball bearing clutches are also available.

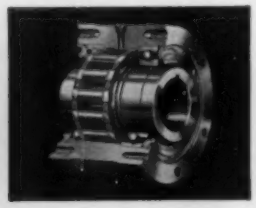
SERIES 400 TO 700 CLUTCHES

These clutches are available in standard Formsprag (FS), High-Performance Over-running (HPO) and High-Performance Indexing (HPI) models. Clutches have either labyrinth or mechanical seals as application requires. Maximum Bore Diameters: ½" to 2¾". Torque Capacities: 95 lbs. ft. to 2,500 lbs. ft.



SERIES 750 TO 1000 CLUTCHES

Standard Formsprag (FS), Holdback (HB), High-Performance Over-running (HPO) and High-Performance Indexing (HPI) clutches have either mechanical or labyrinth seals. Maximum Bore Diameters: 2" to 6". Torque Capacities: 1,900 lbs. ft. to 13,500 lbs. ft.



LARGE BORE HOLDBACKS

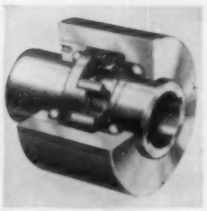
Formsprag large bore clutches are ideally suited for mounting on head shafts of conveyors or any application requiring high torque over-running features. These backstops can be modified for mountings. Maximum Bore Diameters: 6" to 12". Torque Capacities: 18,500 lbs. ft. to 136,500 lbs. ft.

SMALL, LIGHT-DUTY CLUTCHES

Economical light-duty Formsprag clutches transmit maximum torque for their size. These accurate, compact clutches are ideal for business machines, instruments and small industrial machines. Provisions for mounting components such as gears, cams, levers, etc. Maximum Bore Diameters: ¼" to ½". Torque Capacities: 50 lbs. in. to 200 lbs. in.

REV-LOK

Dual Torque-Locking and Positioning Devices Stop Feedback Torque and Provide Two-Directional Positioning, Drive, Over-running, Backstopping and Load-Limiting.

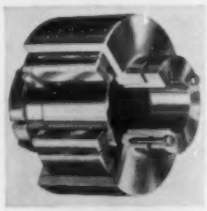


These multi-purpose devices have an exceptionally wide range of application and may be adapted for single revolution and torque limiting functions. They also offer greater torque capacity for their size and weight and permit higher over-running speeds than any similar device.

Standard models having bores or shaft sizes from ¼" to 2½" in diameter provide torque capacities ranging from 40 lbs. in. to 30,000 lbs. in. Smallest sizes have mounting flange on outer race, are permanently lubricated and can be used for end-to-end or coaxial drive. Write for technical bulletin.

RAWSON

Centrifugal Clutches and Clutch-Couplings Provide Cushioned Starts, Overload Protection, Reduced Costs and Improved Motor Performance.



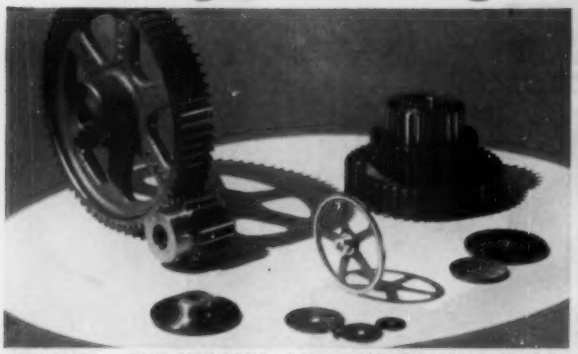
The reliability, compactness and greater capacity of Rawson Clutches have proved especially effective in aircraft applications such as helicopter transmissions.

Used in a wide variety of other applications, Rawson Clutches eliminate the need for costly reduced voltage starting equipment and permit using lower cost smaller motors. Write for catalog.

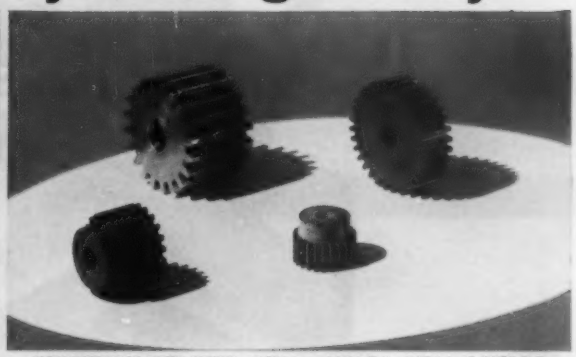
Precision Power Transmission Products

FORMSPRAG COMPANY
23607 HOOVER ROAD, DEPT. 108-A
WARREN (Detroit), MICHIGAN

Design around gears you can get today



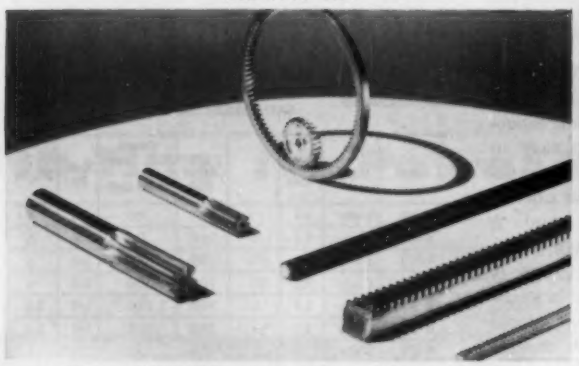
SPUR GEARS — STEEL, IRON, BRASS 14½° and 20° P.A. .208" to 40" P.D.



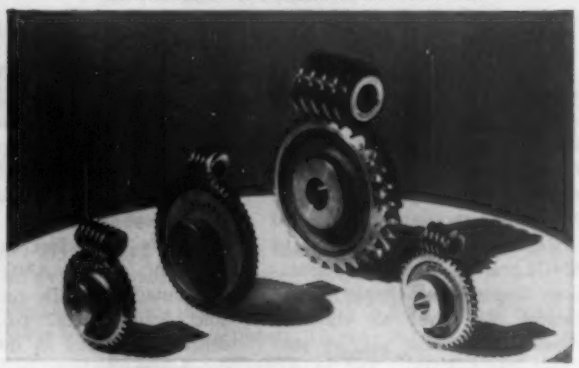
NON-METALLIC SPUR GEARS 14½° and 20° P.A. .938" to 6.667" P.D.

BEVEL and MITER GEARS Steel, Iron, and Brass 20° P.A. .312" to 14" P.D.

STEEL SPIRAL MITERS 1" to 5" P.D.
HELICAL GEARS Steel and Bronze .333" to 6" P.D.



RACK • PINION WIRE Steel and Brass 14½° and 20° P.A.
PINIONS • INTERNAL GEARS



WORM GEARS Bronze and Iron .417" to 18" P.D.
WORMS .333" to 4" P.D. Soft steel and hardened and ground steel

Build it better...for less...without delay

Design around standardized BOSTON Gears FROM STOCK is the quickest (and lower-cost) way to get your project "off the board" and in production — whether it's a prototype, a product for resale, or new equipment for your own plant. Catalog No. 57 lists over 2000 gears.

Your nearby Distributor will help you simplify planning and show you how to get the biggest benefits from BOSTON Gear standardization — in lower costs, in easier maintenance, in simplified servicing. Boston Gear Works, 71 Hayward St., Quincy 71, Mass.

OFF-THE-SHELF
FROM STOCK
AT FACTORY PRICES

CALL YOUR NEARBY BOSTON Gears DISTRIBUTOR

"Yellow Pages"

— STANDARDIZATION PAYS —

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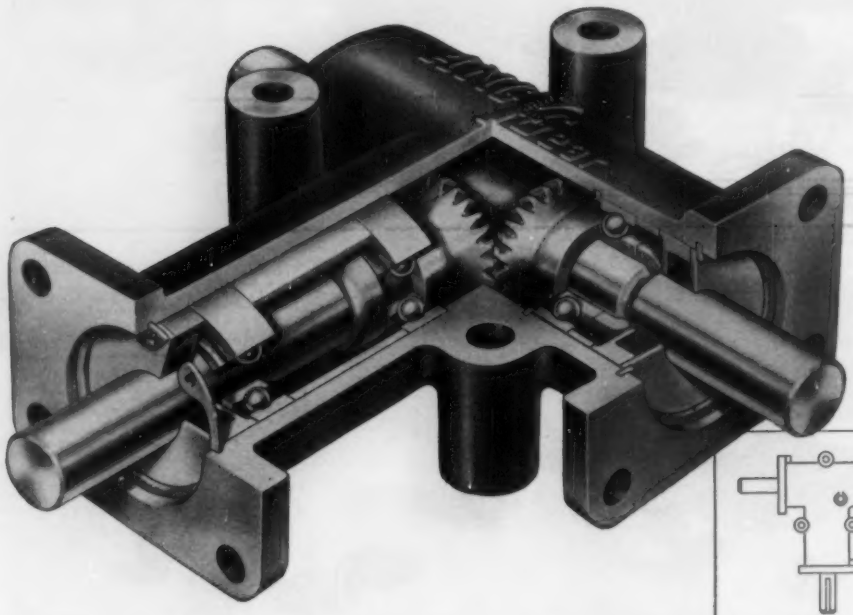
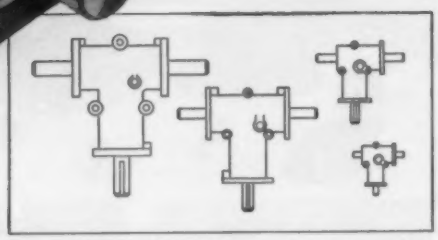
CIRCLE 225 ON READER SERVICE CARD 225

There is only one ANGLgear®... and it is made only by Airborne



Quality of ANGLgear construction is evident in cutaway view. ANGLgear gives you all the features of other drives, plus greater hp range (⅛ to 5); permanent lubrication; and Coniflex* design gears for more even load distribution, reduced wear, quieter operation.



ANGLgear is available from local distributor stocks in 4 sizes, 16 models, with various gearing and shaft options.

ANGLgear – introduced in 1951– is the *original* standardized right-angle drive. It is also the No. 1 product in its field – in sales, availability, quality, performance. Witness the thousands of satisfied customers who have bought ANGLgear to date – for applications ranging from simple manual control of valves to classified installations aboard nuclear submarines.

In design and construction, ANGLgear has been refined to the point of being virtually foolproof, provided it is not grossly overloaded. Take a unit off the shelf, install it, run it–for years. And attention is seldom required.

Besides being maintenance-free, ANGLgear is also easy to design into your power transmission systems because of its universal mounting feature. And it invariably costs less than other types of drives. ANGLgear is distributed nationally and is available immediately from local distributor stocks in the models listed here. Special sizes, special gear ratios, etc., can also be furnished. For complete engineering data, contact our local distributor, or write direct for new Catalog IA-58. *ANGLgear design template kits are available on request.*

*Trademark of the Gleason Works

BASIC MODEL DATA

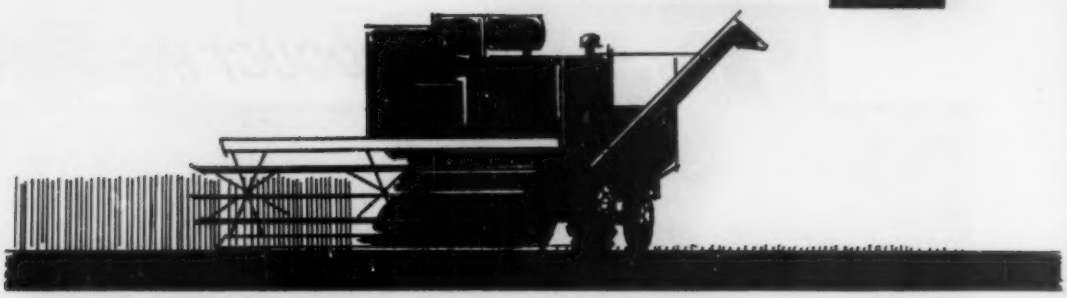
Model	Type	Gear Ratio	HP	RPM Output Shaft	Ultimate Static Torque lb. in. Output Shaft	Shaft Dia.	Wt., lb.
R-300	2-way	1:1	1/3	1800	250	3/8	.5
R-300-2	2-way	2:1	1/5	1800	250	3/8	.5
R-310	3-way	1:1	1/3	1800	250	3/8	.5
R-310-2	3-way	2:1	1/5	1800	250	3/8	.5
R-320	2-way	1:1	1	1800	1000	5/8	2.2
R-320-2	2-way	2:1	3/5	1800	1000	5/8	2.2
R-330	3-way	1:1	1	1800	1000	5/8	2.4
R-330-2	3-way	2:1	3/5	1800	1000	5/8	2.4
R-333	2-way	1:1	2-1/4	1200	1500	3/4	8.7
R-333-2	2-way	2:1	2-1/4	1200	1500	3/4	8.7
R-335	3-way	1:1	2-1/4	1200	1500	3/4	9.0
R-335-2	3-way	2:1	2-1/8	1200	1500	3/4	9.0
R-340	2-way	1:1	5	1200	2500	1	14.5
R-340-2	2-way	2:1	5	1200	2500	1	14.5
R-350	3-way	1:1	5	1200	2500	1	15
R-350-2	3-way	2:1	5	1200	2500	1	15

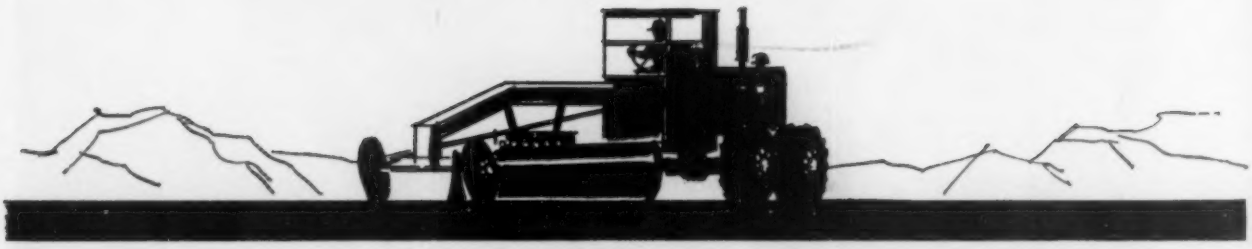
AIRBORNE®

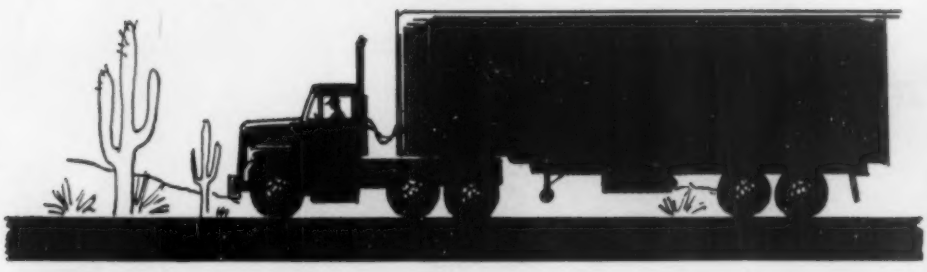
Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY







No Time for Power Transmission Failure

When there are crops to be harvested, roads to be built, delivery schedules to be met . . . this is no time for repair or maintenance downtime.

That's why so many original equipment manufacturers look to Borg-Warner for dependable, stay-on-the-job power transmission components. To Borg & Beck and Long Manufacturing divisions for clutches and torque converters. To B-W's Morse Chain Company for timing, silent and roller chains, speed reducers and flexible couplings. To Warner Automotive division for gear boxes, conventional and spin-resistant differentials, and power train assemblies. To Rockford Clutch division for heavy duty clutches and power take-offs. To Mechanics Universal Joint division for roller bearing universal joints and propeller shafts of all types and sizes. To Spring division for torque converter parts and subassemblies. To Warner Gear division for standard and automatic transmissions.

The 7 Hats of Borg-Warner . . . *(top)* National defense; oil, steel and chemical; *(middle)* agriculture; industrial machinery; aviation; *(bottom)* automotive industry; home equipment.

Right from its start, Borg-Warner has pioneered and set the pace in advanced-design power transmission products. And today, through creative research and engineering, Borg-Warner continues to develop still better products for your needs of tomorrow.

B-W

BORG-WARNER

BETTER PRODUCTS THROUGH CREATIVE RESEARCH AND ENGINEERING

Borg-Warner Corporation • 200 South Michigan Avenue • Chicago 4, Illinois

CIRCLE 227 ON READER SERVICE CARD 227

PRODUCT INFORMATION

N/D sound booth for analysis of electric motor noise, mounted on springs and constructed with non-parallel walls, assures manufacturers a *scientific solution* to electric motor noise problems. Motors are tested with special electronic sound evaluation equipment.

How N/D Minimizes Electric Motor Noise!

In New Departure's full-time noise analysis program, a unique sound booth and special electronic sound level equipment are used to pinpoint and evaluate electric motor noise. Inside the booth, a condenser microphone picks up air-borne noise from the running motor. Outside, the signal is electronically registered and recorded.

By changing one variable at a time, such as bearing or mounting design, or lubricant, N/D engineers are able to select the proper combination that results in the quietest motor operation. That's why you'll find New Departure precision ball bearings specified for electric motors to be used in quality home appliances, instruments, fans, hand tools and other applications . . . for greater consumer sales appeal.

If you have an electric motor noise problem, contact the N/D Sales Engineer in your area. For additional information call or write New Departure Division, General Motors Corporation, Bristol, Connecticut.

NEW DEPARTURE
BALL BEARINGS
proved reliability you can build around

DYNAMIC POWER CONTROL
by ROCKFORD

CLUTCHES, POWER TAKE-OFFS AND SPEED REDUCERS

Positive, full-motion driving power with cushioned starts and controllability . . . this is Dynamic Power Control. Rockford automotive and industrial clutches transmit smooth and instantaneous power to light, medium or heavy work loads. Torque loads range from 126 inch lbs. to 3,235 foot lbs.! Sizes vary from the compact 1¾" dia. Pullmore Clutch to the giant 17" Over-Center unit. Applications range from small machine tools to heavy road building equipment. Rockford will help solve your control problems. *Write today for illustrated brochure.*

SPRING-LOADED CLUTCHES

These rugged clutches are used on motor trucks, cars, farm tractors, graders, and other wheeled vehicles where the clutch is in almost constant engagement. The clutch is disengaged by foot pedal or hand lever pressure.

OVER-CENTER CLUTCHES

The clutches with built-in durability are used on agricultural machinery, cranes, tractors, concrete mixers, compressors, excavators, pumps, oil field and road-building equipment where disengagement and engagement may be for long periods of time.

PULLMORE MULTIPLE-DISC CLUTCHES

Compact Pullmore Clutches are used on metalworking machines, machine tools, materials handling equipment, dairy and confectionery machinery, winches, spring coilers, blueprint machines, and other industrial equipment. Pullmore Clutches provide smooth starting by hand or booster control. Oil or dry operation.

POWER TAKE-OFFS

Rockford's efficient PTO's are used on independent power units and built-in engines for powered equipment. Rockford PTO's are available with light or heavy duty Over-Center Clutches. They are suitable for all internal combustion engines in a wide range of sizes to fit standard S.A.E. flywheel housings.

SPEED REDUCERS

Heavy-duty gear reduction units are used to transmit power from internal combustion engines to output shafts where speeds are required to be slower than engine speeds. They are available in a wide range of sizes to fit standard S.A.E. flywheel housings.

ROCKFORD CLUTCHES

ROCKFORD CLUTCH DIVISION BORG-WARNER

209 CATHERINE STREET ROCKFORD, ILL.

CIRCLE 229 ON READER SERVICE CARD 229

IMMEDIATE DELIVERY!

ON 3/8" AND 1/2" O.D.

Non-Magnetic

18-8 TYPE 303 STAINLESS

UNIVERSAL JOINTS

Manufacturers of electronic equipment have come to depend on Curtis for precision-made non-magnetic universal joints of 18-8 Type 303 stainless steel, in the sizes most frequently used in the industry. Other sizes are also readily available; also bronze joints.

Curtis joints benefit by a rigid insistence on uncompromising inspection and quality control at every stage of manufacture, insuring minimum backlash.

Curtis torque and load ratings are entirely dependable, since they are based on continuous testing under actual operating conditions.

Not sold through distributors. It will be to your advantage to write or phone (REpublic 7-0281) for free engineering data and price list.

CURTIS TRADE MARK

UNIVERSAL JOINT CO., INC.
119A Birnie Avenue, Springfield, Mass.

As near to you as your telephone

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

catalogs and bulletins.....continued

(E-62) Miniature Magnetic Clutches and Brakes—Catalog, 19 pp. Contains dimensioned drawings, ratings, performance curves. Includes tension controls and flexible couplings. Dial Products Co, 19 Cottage St, Bayonne, NJ.

(E-63) Short Pitch Chain—Bulletin, 4 pp. Describes nonmagnetic stainless steel roller chain with pitch of 0.1475 in. for instrument or electronic use. Also sprockets. Diamond Chain Co, Inc, 402 Kentucky Ave, Indianapolis, Ind.

(E-64) Magnetic Disc Brakes—Bulletin, 8 pp. Presents dimensions, capacities for units for motors to 50 hp. Dings Brakes, Inc, 4740 W Electric Ave, Milwaukee 46, Wisc.

(E-65) Worm Gear Speed Reducers—Bulletin, 24 pp. Furnishes drawings, ratings and load factors for fan-cooled reducers. Ratings to 39.6 hp. Cleveland Worm & Gear Div, Eaton Mfg Co, 3300 E 80 St, Cleveland 4.

(E-66) Electric Speed Control—Bulletin, 16 pp. Describes eddy-current couplings, drives, brakes, dynamometers and magnetically controlled clutches and brakes. Dynamatic Div of Eaton Mfg Co, 3122 14 Ave, Kenosha, Wisc.

(E-67) Disc Clutches—Four bulletins, 15 pp. Provides ratings, dimensions for gear, shaft, pulley, pin drives. Includes slip clutches. The Edgemont Machine Co, 2200 Home Ave, Dayton 17, Ohio.

(E-68) Solid Film Lubricants—Brochure, 16 pp. Liquids air dry or heat cure. Describes application procedure for corrosion resistant, high temperature and other lubricants. Electrofilm, Inc, Box 106 N Hollywood, Cal.

(E-69) Belting—Catalog, 8 pp. Shows how to select and maintain power transmission belting. Characteristics and construction shown. Extremultus, Inc, 25-11 40 Ave, LI City, NY.

(E-70) Lubrication—Bulletin, 8 pp. Explains construction, operation and selection of manual or automatic spray lubricating systems for heavy industrial gearing, sliding surfaces. Farval Div, Eaton Mfg Co, 3290 E 80 St, Cleveland.

(E-71) Instrument Power Transmission—Brochure, 12 pp. Describes instrument drives, gear boxes, flexible shafts, manual and magnetic clutches and others. Also mechanical tachometers. Actuator Products, Div of Geartronics Corp, 40 Nashua St, Woburn, Mass.

(E-72) Variable Speed Drive—Brochure; 16 pp. Presents packaged system consisting of controls, m-g set and dc motor. General Electric Co, Dc Motor & Generator Dept, 3001 E Lake Rd, Erie 1, Pa.

(E-73) Variable Speed Drive—Bulletin, 12 pp. Presents packaged unit consisting of ac motor, eddy current coupling and couplings controls. General Electric Co, Dc Motor & Generator Dept, 3001 E Lake Rd, Erie 1, Pa.

(E-74) Variable Speed Drive—Bulletin, 8 pp. Presents a packaged system utilizing rectified ac current and dc motor. Rated one to 200 hp. General Electric Co, Dc Motor and Generator Dept, 3001 E Lake Rd, Erie 1, Pa.

(E-75) Electric Drive for Off-highway Vehicles—Brochure, 7 pp. Presents performance data and specifications; discusses advantages and applications. General Electric Co, Bldg 3-42, 2901 E Lake Rd, Erie, Pa.

(E-76) Variable Speed Pulleys—Bulletin, 24 pp. Gives ratings, dimensioned drawing and application tables for variable speed pulleys, ratio compound drives, motor bases and frames, belts and belt sheaves. Hi-Lo Mfg Co, affiliate of Lovejoy Flexible Coupling Co, 4945-4949 W Lake St, Chicago.

(E-77) Universal Joints—Catalog, 8 pp. Presents load ratings, dimensions and installation instructions for joints from ¾ to 7¾ in. OD. Gray & Prior Machine Co, 614 Windsor St, Hartford, Conn.

(E-78) Die Cast Zinc Gears—Catalog, 9 pp. Presents dimensions, specifications for gears, gear and pinion sets of many configurations. Gries Reproducer Corp, 159 Beechwood Ave, New Rochelle, NY.

(E-79) Flexible Couplings—Catalog, 5 pp. Gives dimensions and ratings for couplings to handle from 1/15 to 48 hp. Guardian Products Corp, 1215 E Second St, Michigan City, Ind.

(E-80) Flexible Shafting—Catalog, 12 pp. Provides data on shafting, casings and fittings for up to 310 in.-lbs running torque. Hasemann Flexible Shaft Co, Inc, 110 Summit Ave, Chatham, NJ.

(E-81) Speed Reducers—Catalog, 24 pp. Spiral bevel gear reducers give up to 357 to 1 ratios. Ratings, load factors and other aids enable selection. Hewitt-Robins, Inc, Stanford, Conn.

(E-82) Slip Clutches, Couplings—Bulletin, 8 pp. Describes devices for constant torque or overload protection. Rated 24 to 24,600 ft-lbs torque. The Hilliard Corp, 100 W Fourth St, Elmira, NY.

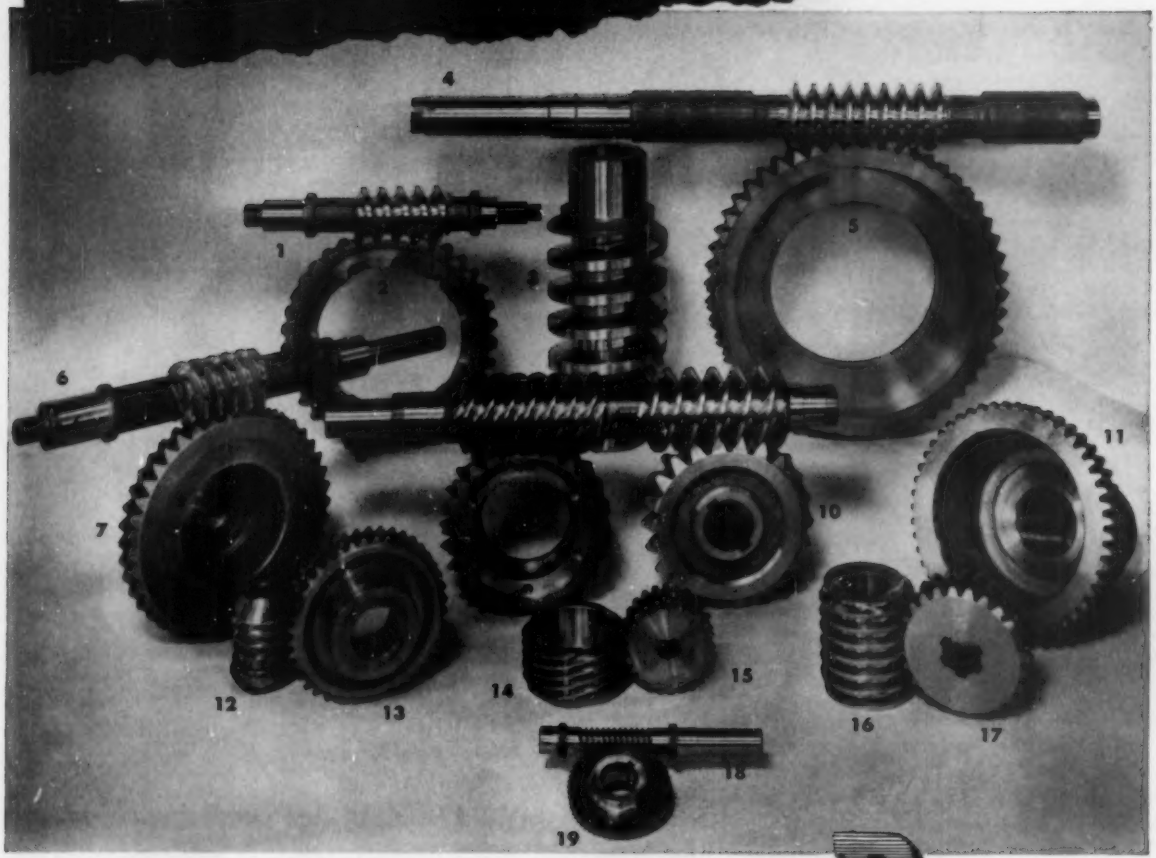
(E-83) Single Revolution Clutches—Bulletin, 8 pp. Gives dimensions, capacities, installation arrangements for clutches which disengage within one revolution of signal. The Hilliard Corp, 100 W Fourth St, Elmira, NY.

continued

BAUSH WORM GEARING

FOR ALL INDUSTRIAL APPLICATIONS

MADE TO YOUR SPECIFICATIONS!!



Be sure you have the exact gear you want — a QUALITY GEAR made to your particular requirements — checked 100% for tooth contact, center distance and Rockwell Hardness — at the right price too!!

BAUSH WORMS AND GEARS shown are a product of over 500 worm gear hobs we maintain at all times. Ranging from sets on 2⅛" center to 28" center, they cover up to and including 2" circular pitch.

YOUR SPECIFIC GEAR NEED CAN BE DESIGNED AROUND THESE HOBS ELIMINATING EXPENSIVE TOOLING AND DELAY.

Write for Catalog No. 12A or send us your prints — there is no obligation.

BAUSH
MACHINE TOOL CO.
SPRINGFIELD 7, MASSACHUSETTS

1 & 2 — Lift Truck
3 — Bending Roll Drive
4 & 5 — For Multiple Spindle Lathe
6 & 7 — Agitator Drive
8, 9 & 10 — 2-Speed Lathe Reduction
11 — Mixing Machine Gear
12 & 13 — Hourglass Type Worm & Wheel
14 & 15 — Lubrication Pump Drive
16 & 17 — Feed Drive-Automatic Machine
18 & 19 — Cutter Drive-Keyseating Machine

CIRCLE 231 ON READER SERVICE CARD 231

FALK

...a good name in industry

QUALITY GEAR DRIVES and FLEXIBLE SHAFT COUPLINGS

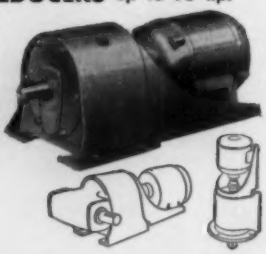
THE FALK CORPORATION, MILWAUKEE 1, WIS. *Representatives and Distributors in many principal cities.*

● The helical and spiral bevel gears in Falk gear drives assure maximum mechanical efficiency attainable — 98½% per gear mesh under full load.

ALL-MOTOR MOTOREDUCERS *up to 75 hp.*

All-steel units for use with any NEMA foot-mounted motors within rated capacities of the gear drives. Standard output speeds from 1 to 780 rpm (with 1750 rpm motors); as low as .032 rpm in semi-standard designs. Also Integral units, from 1 to 40 hp.

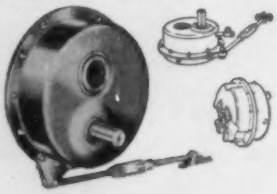
Ask for Bulletin 3100.



SHAFT MOUNTED DRIVES *up to 50 hp.*

All-steel units, horizontal or vertical. Output speeds between 420 and 5 rpm. Maximum torque rating at low speed shaft: 44,000 lb-in. Consult Factory for higher capacities and for flange mounted drives.

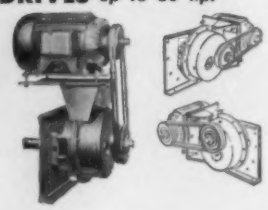
Ask for Bulletin 7100.



SCREW CONVEYOR DRIVES *up to 30 hp.*

Bolt to any standard trough end. Output speeds from 420 to 5 rpm. Max. torque rating at low speed shaft: 21,400 lb-in. Drive includes removable drive shaft and seal housing with choice of seals. Trough end and Motor Mount optional.

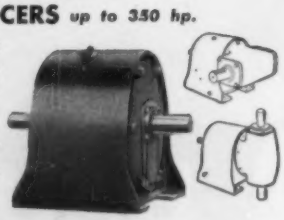
Ask for Bulletin 7106.



SMALL SPEED REDUCERS *up to 350 hp.*

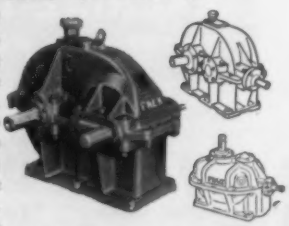
Concentric Shaft reducers with ratios from 1.49:1 to 970:1. Maximum torque at low speed shaft: 84,000 lb-in. **Right Angle** ratios from 5:1 to 1460:1. Maximum torque at low speed shaft: 73,000 lb-in.

Ask for Bulletin 1105.



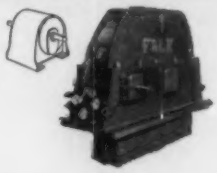
LARGE SPEED REDUCERS *up to 3500 hp.*

Parallel Shaft up to 3500 hp. Ratio range: from 2:1 to 300:1. Maximum catalog torque at low speed shaft: 1,950,000 lb-in. Bulletin 1110. **Right Angle Horizontal** up to 1000 hp. Ratio range from 1.5 to 515:1. Max. catalog torque at low speed shaft: 569,000 lb-in. Bulletin 2105. **Right Angle Vertical** up to 760 hp. Ratio range from 6:1 to 430:1. Max. catalog torque at low speed shaft: 714,000 lb-in. Low speed shaft extension up or down. Bulletin 2110.



HIGH SPEED DRIVES ... *reducers or increasers.*

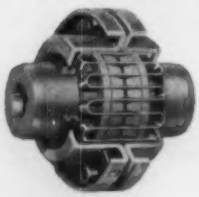
Parallel Shaft drives cataloged up to 5,000 hp or 10,000 rpm. Unit ratios from 1.15:1 to 12:1. Bulletin 5105. **Concentric Shaft** units cataloged up to 225 hp or 4500 rpm. Ratios from 1.5:1 to 25:1. Bulletin 1106.



STEELFLEX COUPLINGS *protect connected machines.*

Hp range: ½ through 72,000 hp at 100 rpm. Exclusive grid-groove design cushions shock loads, accommodates reasonable degrees of shaft misalignment. Basic Type F for 9 out of 10 industrial applications, horizontal or vertical.

Ask for Bulletin 4100.



Basic Type F

AIRFLEX COUPLINGS *Designed for mounting shaft-to-shaft, shaft-to-flywheel, or shaft-to-flange.*

15 sizes covering a range from 5 through 2880 hp at 100 rpm. Ideal for applications which have irregular torque characteristics in driving or driven machines (internal combustion engines, reciprocating compressors, etc.).

Ask for Bulletin 8100.

SINGLE HELICAL and HERRINGBONE GEARS

Exclusive Falk extra-depth, high pressure angle gear teeth provide greater strength and protection against abrasion. AGMA ratings. Hub or ring gears in solid or split designs.

Diameters up to 23'-9" PD.

Face widths up to 6'.

Diametral Pitch: ¾ to 6 DP.

Ask for Engineering Reports 6170 and 6171

Ring Gears

Hub Gears

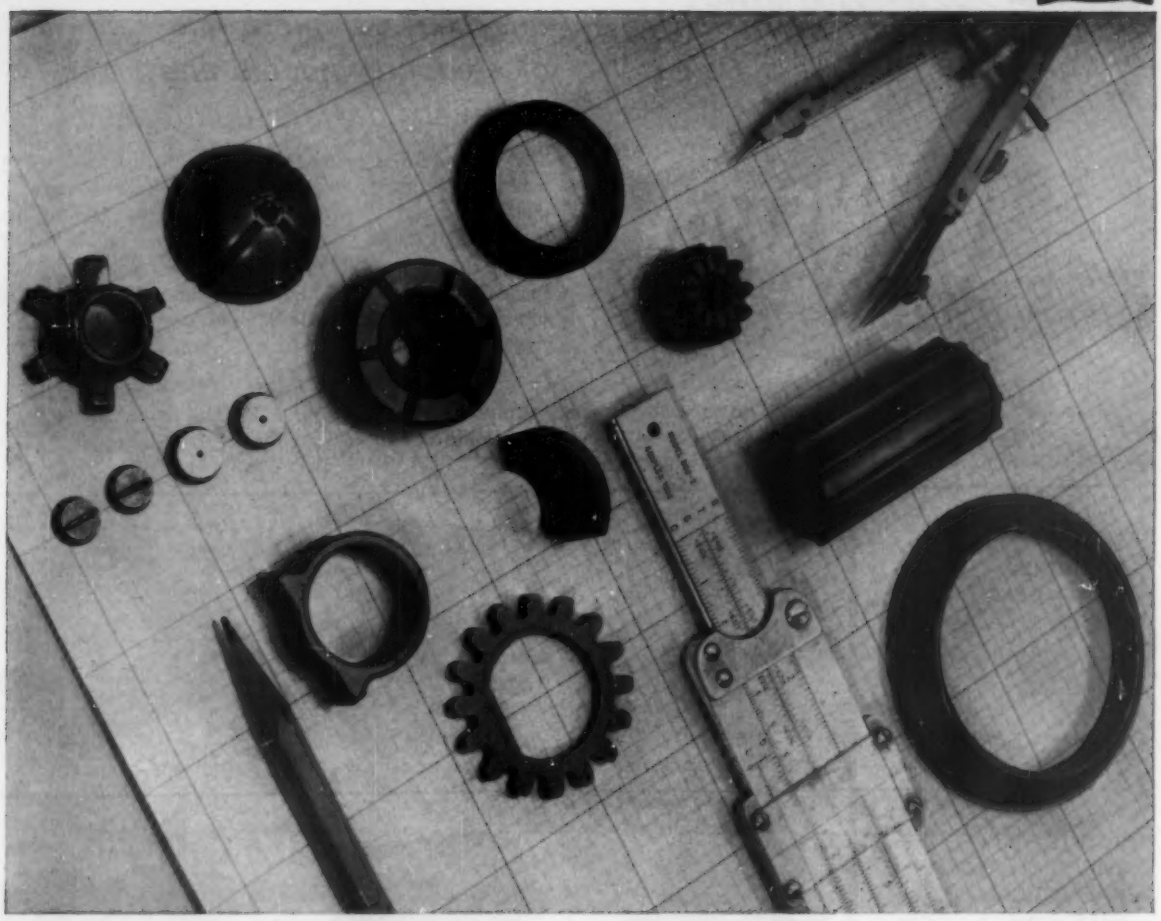
Special GEAR DRIVES for any application.

Special HIGH SPEED DRIVES ... over 50,000 rpm.

Marine PROPULSION DRIVES for turbine and diesel.

FALK, ALL-MOTOR, and STEELFLEX are registered trademarks.

CIRCLE 232 ON READER SERVICE CARD



Need Close Tolerance Parts Like These?

You'll save money if Johnson Bronze makes them for you in Powdered Metals

Making parts like these in powdered metal—quickly, economically and in production tolerances of *.001 of an inch or closer*—is a tradition at Johnson Bronze Co.

That's why Johnson powdered metals—ferrous and non-ferrous—have been in demand for over 20 years. Quality and dollar-conscious engineers know from experience that Johnson powdered metal parts consistently meet material quality and close tolerance requirements.

These engineers also know they can rely on the experience of Johnson's complete product design engineering service. It's one of the many bonuses from using Johnson powdered metal parts. Here's another: *Johnson now can supply powdered metal parts up to 4 inches O.D. and 3 inches long.*

If you need any parts like those shown here, call, write or wire Johnson Bronze Co.

Johnson Bronze Company

New Castle, Pa.

West Coast Plant: Oakland 8, Calif.

CIRCLE 233 ON READER SERVICE CARD 233

WINSMITH
SPEED REDUCERS

the most complete line of standard models and sizes for every design requirement

The Winsmith line of conventional and hollow shaft speed reducers offers design engineers and speed reducer users the widest range of standard models and capacities available from a single source of supply.

For precise, dependable performance—top operating efficiency at all speeds and ratios—maintenance-free durability and overall economy, specify Winsmith Speed Reducers for every application from 1/100 to 85 h.p., in ratios from 1.1:1 to 50,000:1.

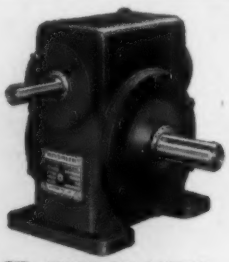
If you have a special problem—consult the Winsmith Representative in your area, or write directly to our Engineering Department.

SINGLE REDUCTION WORM GEAR TYPE

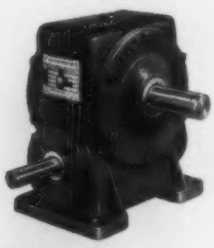
14 Sizes — .01 hp to 34 hp

Ratio Range — 5:1 to 77:1

Maximum Output Torque 142 to 34,767 in. lbs.



CB—WORM ON BOTTOM



CT—WORM ON TOP

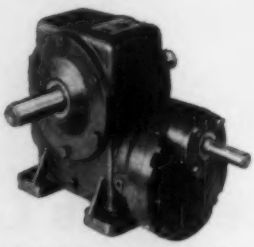
CV—VERTICAL

DOUBLE REDUCTION WORM AND HELICAL GEAR TYPE

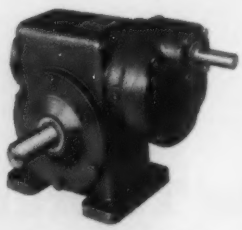
10 Sizes — .3 hp to 11.86 hp

Ratio Range — 42:1 to 231:1

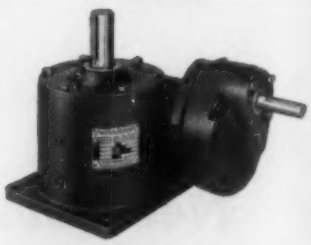
Maximum Output Torque 1331 to 34,767 in. lbs.



CBX—WORM ON BOTTOM



CTX—WORM ON TOP



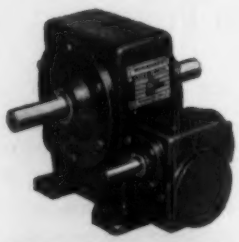
CVX—VERTICAL

DOUBLE REDUCTION WORM GEAR TYPE

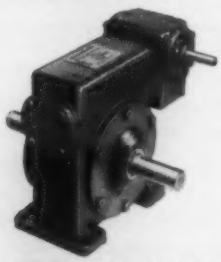
12 Sizes — .018 hp to 7.41 hp

Ratio Range — 60:1 to 4460:1

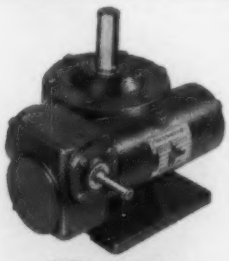
Maximum Output Torque 650 to 34,767 in. lbs.



CBD—WORM ON BOTTOM

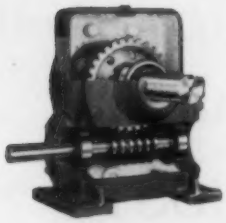


CTD—WORM ON TOP



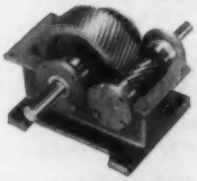
CVD—VERTICAL

complete engineering data and selection information for you



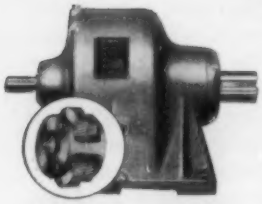
WORM GEAR REDUCERS

Single or double reduction models, for service in either intermittent or continuous operation. Available with right-angle or parallel shafts; worm on top or bottom; all worm gear or combined worm and helical.



HELICAL GEAR REDUCERS

Single reduction, parallel shaft units for small ratios. Hardened, accurately ground, alloy steel pinion shafts. Cast iron gears.



DIFFERENTIAL GEAR REDUCERS

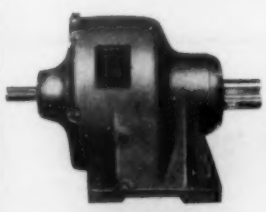
Winsmith offers a unique, patented type of differential gear reducer in which the planetary and secondary gears are integrated to form a unified planetary element. Tooth alignment is improved because the planetary gears automatically float into position, thus equalizing load distribution. Parts are never increased in number, regardless of reduction ratios—from 1.1:1 to 50,000:1—and the over-all dimensions of a given size never vary.

DIFFERENTIAL REDUCERS

.12 hp to 81.51 hp

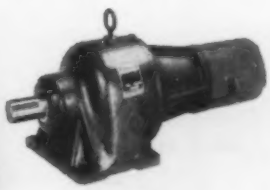
Ratio Range — 1.1:1 to 50,000:1

Maximum Output Torque
50 to 113,000 in. lbs.



HORIZONTAL

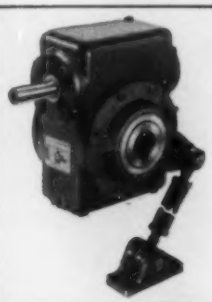
FLANGE MOUNTED



MOTORIZED — VERTICAL, HORIZONTAL

HOLLOW SHAFT WORM GEAR SPEED REDUCERS

Torque Arm and Flange Mounted models available in both series.

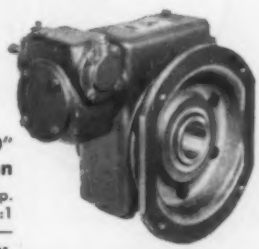


SERIES "ST" & "SF"
Single Reduction

3 Sizes — .63 to 8.82 hp.
Ratio Range — 7½:1 to 77:1
Maximum Output Torque —
816 to 7678 in. lbs.

SERIES "STD" & "SFD"
Double Reduction

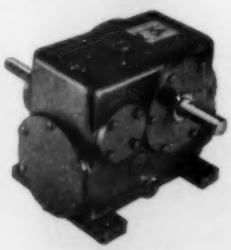
3 Sizes — .041 to 2.552 hp.
Ratio Range — 66⅔:1 to 4466:1
Maximum Output Torque —
1380 to 7678 in. lbs.



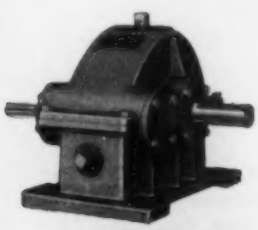
1. DOUBLE REDUCTION WORM GEAR TYPE
9 Sizes — .006 hp to 7.319 hp
Ratio Range — 25:1 to 3850:1
Maximum Output Torque
146 to 34,290 in. lbs.

2. SINGLE REDUCTION HELICAL GEAR HORIZONTAL TYPE
3 Sizes — .05 hp to 18.86 hp
Ratio Range — 3.06:1 to 12.66:1
Maximum Output Torque
294 to 3682 in. lbs.

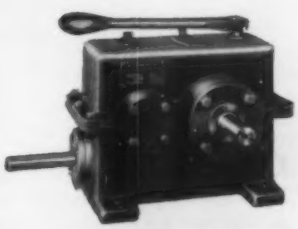
3. TWO SPEED REDUCTION WORM AND SPUR GEAR TYPE
2 Sizes — .01 hp to 6.17 hp
Ratio Range — 5:1 to 163:1
Maximum Output Torque
333 to 3089 in. lbs.



1 SERIES **DBI**



2 SERIES **700, 800, 900**



3 SERIES **TSR**

WINSMITH CATALOGS are among the most useful tools ever devised for design engineers. They contain detailed selection information, weights, dimensions, ratios, ratings and other pertinent design data—including cross-section, shaft and mounting arrangement drawings, and large, clear product photographs—all in concise, easy-to-use form.

WRITE TODAY on your company letterhead, for the most authoritative, up-to-date compilation of speed reducer information available.

MEMBER OF AGMA

WINSMITH, INC. 112 Eaton Street, Springville, (Erie County), N. Y.

How INDEX TABLE *DESIGN* affects INITIAL PRICE and TOTAL COST

Study these drawings to see how the design of an index table affects total costs of an installation. Some tables may be priced lower than others initially, but the additional charges for auxiliary items to adapt them to production requirements, added to maintenance and downtime costs, can make a drastic difference in the total price.

The Ferguson Intermittor, indexed by a roller gear drive which operates a minimum of 8,000 hours at speeds up to 2,000 indexes a minute without maintenance, needs no auxiliary locking. It is designed for high speed operation and incorporates rigid integral supports for tooling to eliminate expensive segmental components. The Intermittor dial is supported by tapered roller thrust bearings to withstand heavy loads with little friction. A stationary center tooling support is held rigidly at its top by anti-friction radial bearings and at the bottom by a flanged base bolted to the housing. Hollow center of the support may be used for passage of coolants, fluids, air or vertical shafts to transmit motion to the work surface.

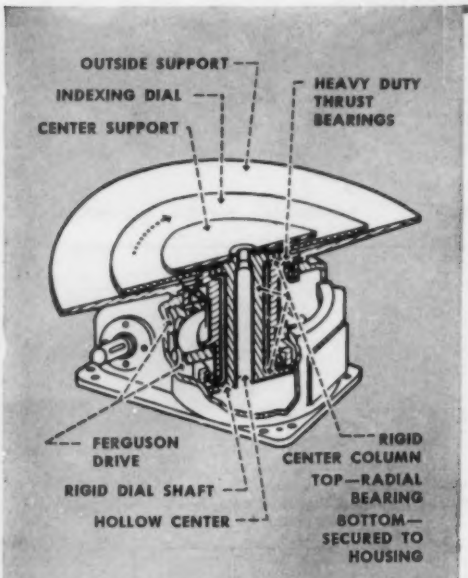


FIG. 1—FERGUSON INTERMITTOR

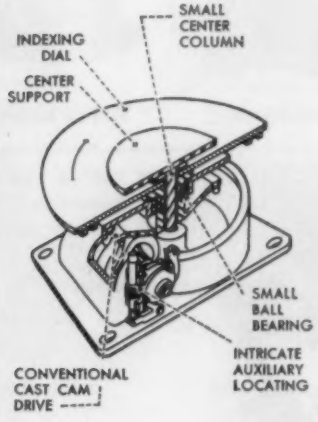


FIG. 2—BARREL CAM TYPE

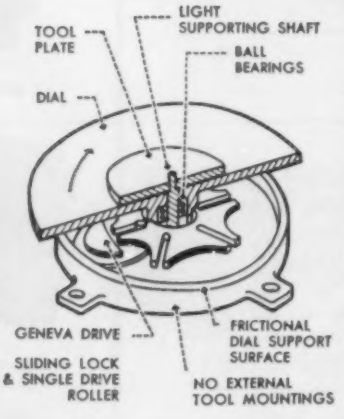


FIG. 3—GENEVA DRIVE TYPE

Figures 2 and 3 show typical barrel cam and geneva drive index tables. Their indexing mechanisms limit operating speeds, therefore other components may be "designed down." Shafts and bearings are lighter; frictional support surfaces might be employed instead of thrust bearings and an auxiliary locking or locating device is a costly necessity for even modest accuracy requirements. Tool mounting methods are often provided at additional expense and sometimes even ignored. Difficulties of installation and frequent maintenance downtime can increase total cost drastically.

• SEND FOR CATALOG

Many other advantages result from the selection of a Ferguson Intermittor. Compare designs in new Catalog No. 160 which contains data on more than 175 standard tables. Every design engineer should have a copy. Get yours by writing:

FERGUSON
MACHINE CORPORATION
A subsidiary of Universal Match Corporation
7818 Maplewood Industrial Court
St. Louis 17, Missouri

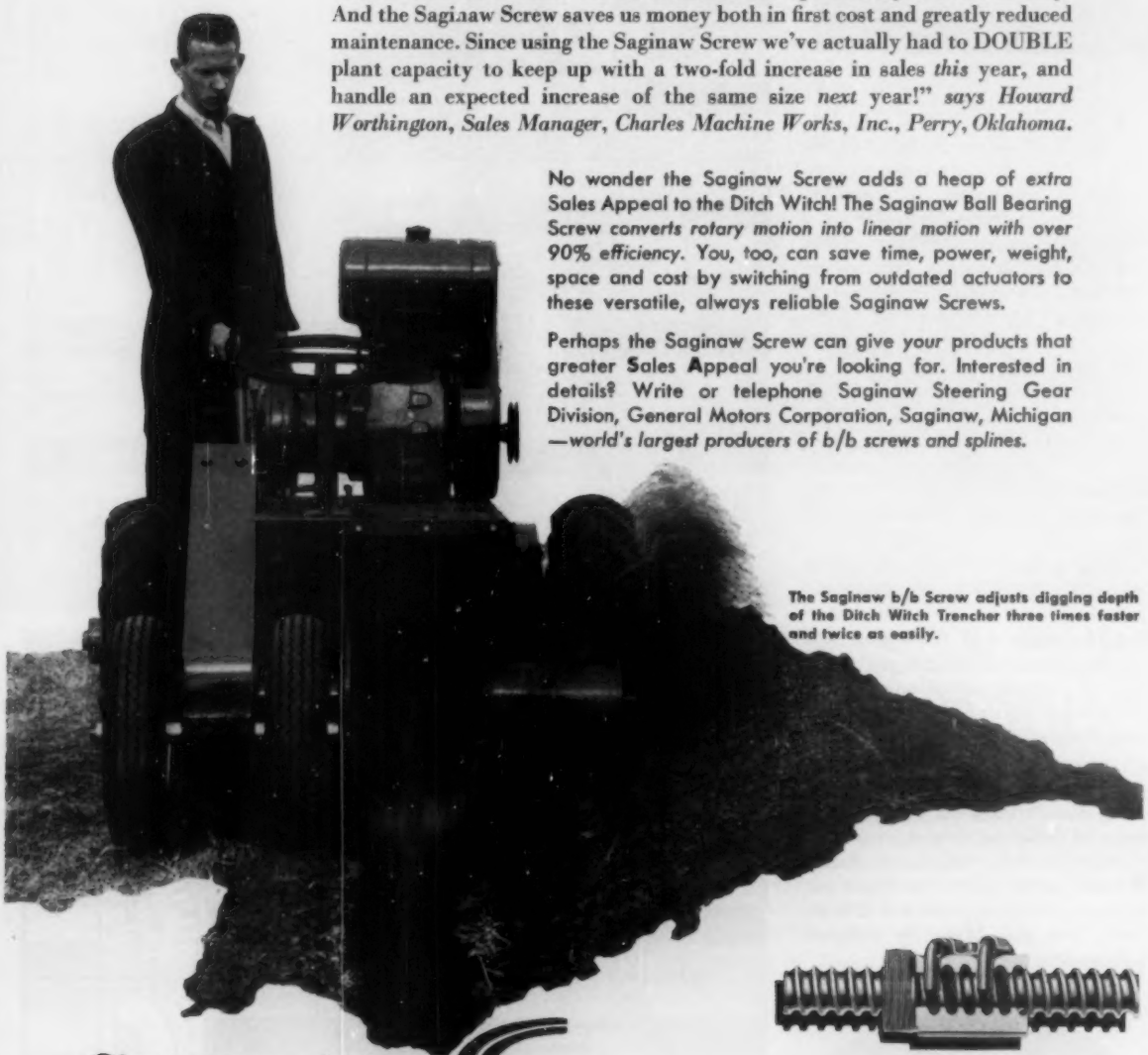
the SAGINAW b/b SCREW helps

Double Ditch Witch Sales in One Year!

"We've replaced an acme screw with a Saginaw Ball Bearing Screw to enable the digging boom of our Ditch Witch Trench Digging machine to be raised and lowered three times faster. It makes the operator's job twice as easy. And the Saginaw Screw saves us money both in first cost and greatly reduced maintenance. Since using the Saginaw Screw we've actually had to DOUBLE plant capacity to keep up with a two-fold increase in sales *this* year, and handle an expected increase of the same size *next* year!" *says Howard Worthington, Sales Manager, Charles Machine Works, Inc., Perry, Oklahoma.*

No wonder the Saginaw Screw adds a heap of *extra* Sales Appeal to the Ditch Witch! The Saginaw Ball Bearing Screw *converts rotary motion into linear motion with over 90% efficiency.* You, too, can save time, power, weight, space and cost by switching from outdated actuators to these versatile, always reliable Saginaw Screws.

Perhaps the Saginaw Screw can give *your* products that greater **S**ales **A**ppeal you're looking for. Interested in details? Write or telephone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan —*world's largest producers of b/b screws and splines.*



The Saginaw b/b Screw adjusts digging depth of the Ditch Witch Trencher three times faster and twice as easily.

Give your products NEW SALES APPEAL... switch to the Saginaw ball bearing Screw

WORLD'S MOST EFFICIENT ACTUATION DEVICE

Unbiased recommendations

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Manual, Air or Hydraulic Operation

To couple an engine or motor to the load, one of the following may be used: a friction clutch, fluid coupling, single-stage torque converter or a three-stage torque converter. Twin Disc can furnish you an unbiased recommendation as to which is the best selection under any given set of circumstances—for Twin Disc offers *all four types of drives.*

No other company builds the diversified line manufactured by Twin Disc. Industrial clutches are offered from 2½ to 36 inches in diameter. Designed to run wet (in oil) or dry, these clutches can be actuated mechanically, hydraulically or with air.

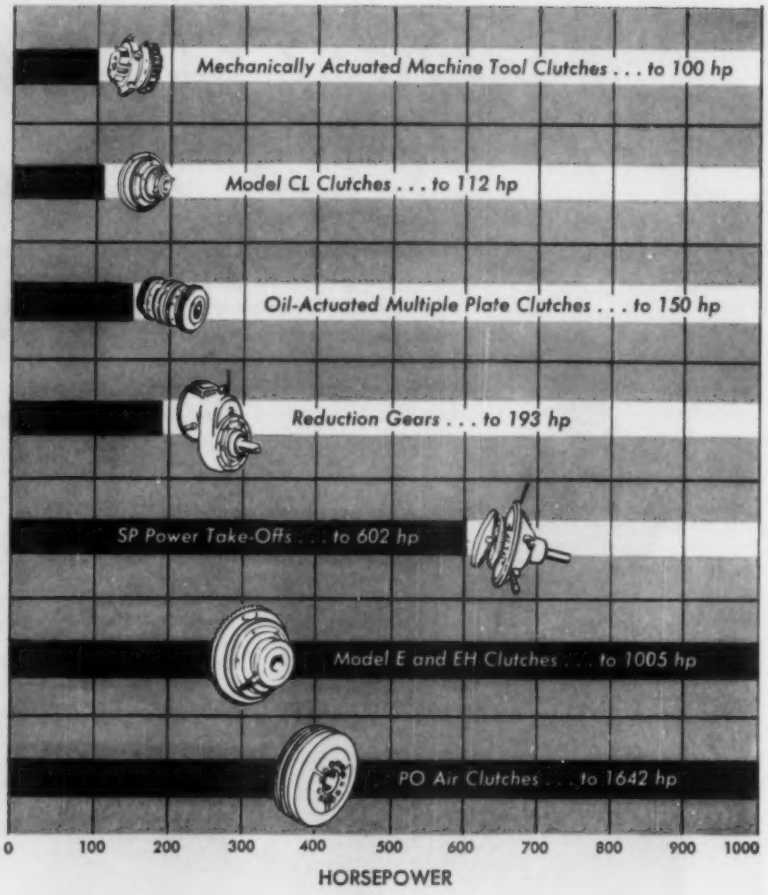
When a fluid drive is necessary or preferable, Twin Disc can recommend just the right one. Twin Disc offers fluid couplings with 1:1 torque ratio . . . single-stage torque converters with up to 3:1 torque multiplication . . . *or* three-stage torque converters with torque ratios up to 6:1. No other manufacturer builds both three-stage and single-stage torque converters . . . no other manufacturer can offer *all three types of industrial fluid drives!*

Whatever drive—friction or fluid—is most appropriate for your own particular application, you'll find it in the Twin Disc line. Write for complete information.

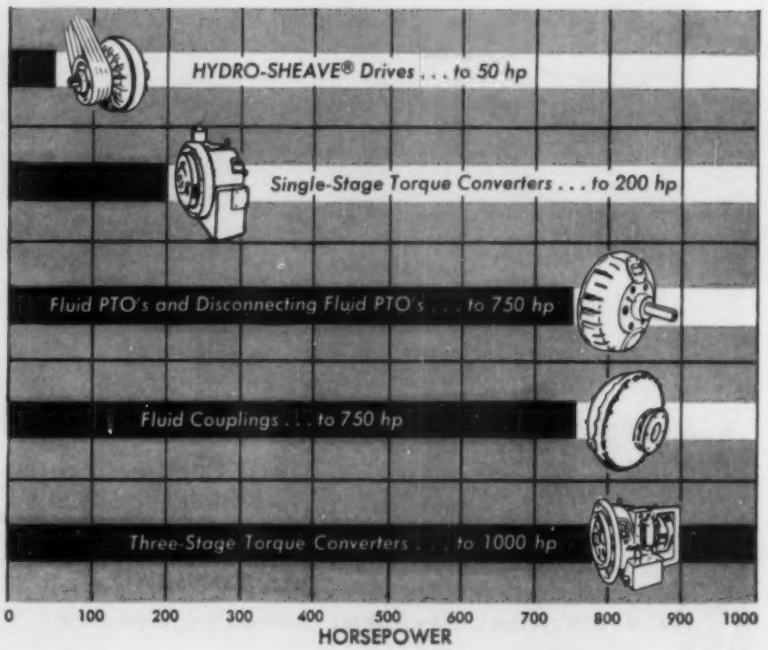
TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC CLUTCH COMPANY
Racine, Wisconsin
Hydraulic Division, Rockford, Illinois

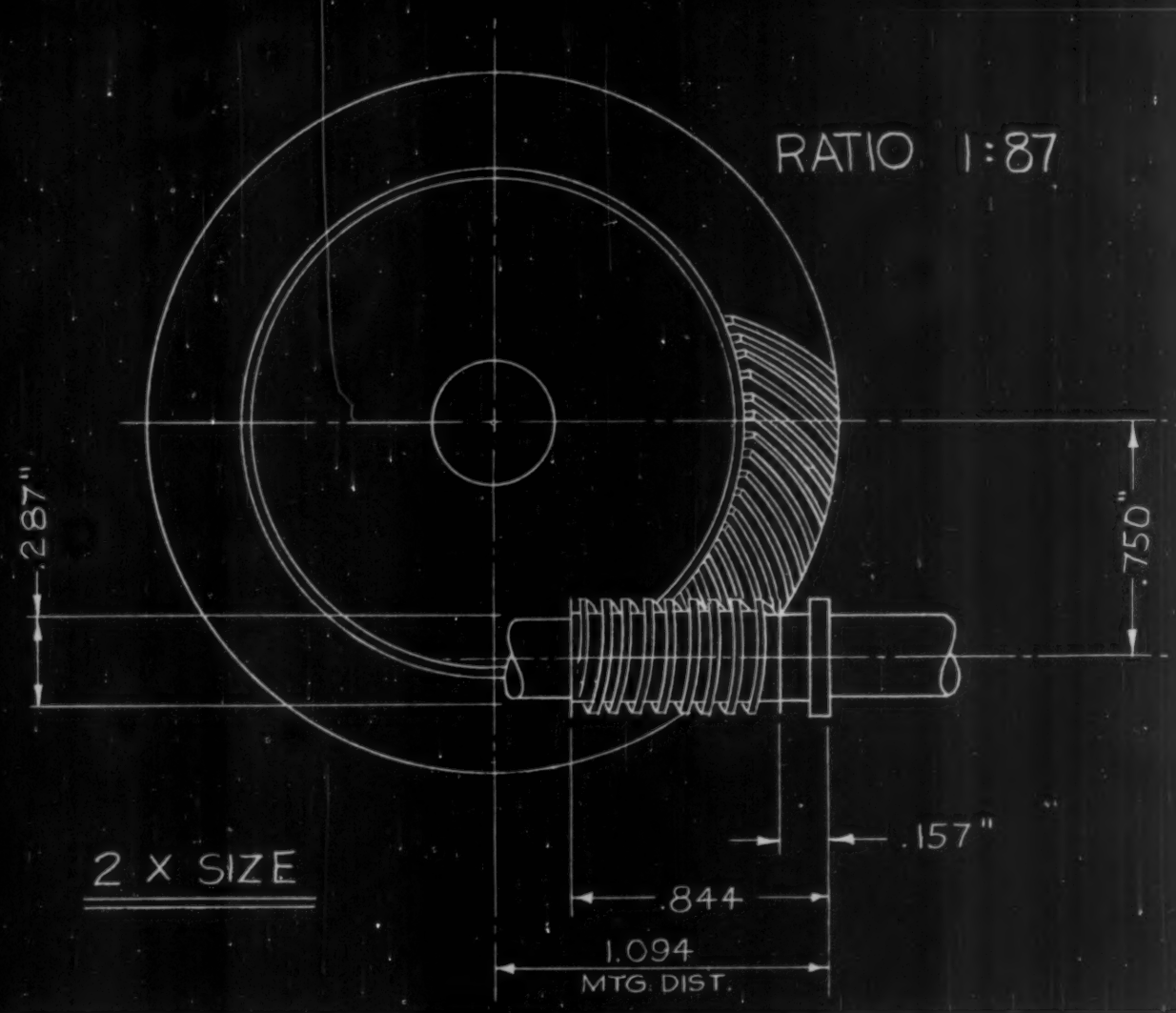
FRICTION DRIVES


Mechanically Actuated Machine Tool Clutches . . . to 100 hp
Model CL Clutches . . . to 112 hp
Oil-Actuated Multiple Plate Clutches . . . to 150 hp
Reduction Gears . . . to 193 hp
SP Power Take-Offs . . . to 602 hp
Model E and EH Clutches . . . to 1005 hp
PO Air Clutches . . . to 1642 hp
0 100 200 300 400 500 600 700 800 900 1000
HORSEPOWER

FLUID DRIVES


HYDRO-SHEAVE® Drives . . . to 50 hp
Single-Stage Torque Converters . . . to 200 hp
Fluid PTO's and Disconnecting Fluid PTO's . . . to 750 hp
Fluid Couplings . . . to 750 hp
Three-Stage Torque Converters . . . to 1000 hp
0 100 200 300 400 500 600 700 800 900 1000
HORSEPOWER

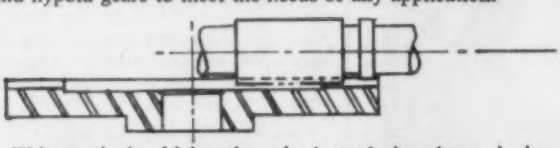
CIRCLE 239 ON READER SERVICE CARD→



HERE'S ANOTHER GEAR GLEASON BUILT FROM FIRST DESIGN TO FINAL PRODUCT

This is the finished prototype of a new high-ratio hypoid gear. Our customer will now produce it, royalty free, on his Gleason equipment.

This is but one example of what Gleason engineering service can do for people who need gears. Our facilities and advice are at your constant disposal for development of bevel and hypoid gears to meet the needs of any application.



This particular high-ratio pair (actual size shown in insert) offers several advantages over conventional gears:

GREATER STRENGTH. High-ratio hypoid pinions are larger and stronger than corresponding bevel pinions.

COMPACTNESS. Where space is a problem, the high-offset principle lets you design a more compact and flexible unit than the corresponding worm and wheel.

SMOOTHER ACTION. High-offset pairs provide smooth, quiet tooth action . . . *continuous* action even with only one or two teeth, because of the way the teeth wrap around the pinion.

STRADDLE MOUNTINGS. Cylindrical high-ratio pinions, with extended shank, make practical very rigid straddle mountings.

GRINDING. High reduction hypoids are cut on same Gleason equipment used on familiar bevel and hypoid gears. Same testers, quenchers and other auxiliary equipment can be used. Grinders are available for the ultimate in precision and finish to minimize friction.

LET GLEASON MAKE RECOMMENDATIONS. Send along a set of prints, and we'll be glad to study them and give you our thoughts on how best to make the gears you need.

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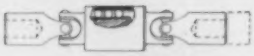
(*Miniature Universal Joints)

TELESCOPING MINI-JOINT

featuring preloaded ball spline and ¼" travel on standard joints.



SIZES IN STOCK

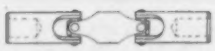
Part No.	Bore*	Body	Closed Length	Torque In. Oz.	Price 1-4 pcs.
T1BS	.0938	3/16	1-7/16	16	28.50
T2BS	.125	3/16	1-7/16	16	28.50
T4BS	.1875	9/32	2	64	28.50
T6BS	.250	3/8	2-1/2	256	28.50

SINGLE MINI-JOINTS

SIZES IN STOCK

Part No.	Bore	Body	Length	Torque In. Oz.	Price 1-4 pcs.
SBS	SOLID	3/16	1-1/32	16	5.50
1BS	.0938	3/16	1-1/32	16	5.90
2BS	.125	3/16	1-1/32	16	5.90
3BS	.156	9/32	1-3/8	64	5.75
4BS	.1875	9/32	1-3/8	64	5.75
5BS	.2188	3/8	1-3/4	256	5.75
6BS	.250	3/8	1-3/4	256	5.75

DOUBLE MINI-JOINTS



SIZES IN STOCK

Part No.	Bore	Body	Length	Torque In. Oz.	Price 1-4 pcs.
DB1BS	.0938	3/16	1-1/2	16	11.90
DB2BS	.125	3/16	1-1/2	16	11.90
DB4BS	.1875	9/32	2	64	11.50
DB6BS	.250	3/8	2-1/2	256	11.50

Features: Zero backlash • Maximum operating angle of 30° • Lightweight • Sealed-in lubrication.

Materials: Body—303 stainless steel • Balls—440 stainless steel • Special assemblies of non-magnetic balls available.

Other instrument components include—
Miniature Coupling • Torque Testing Machine

Inquiries for your special applications are invited.

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205 Concord Turnpike, Cambridge, Mass.

catalogs and bulletins.....continued

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(E-85) Intermittent Drive—Bulletin, 4 pp. Describes packaged unit consisting of single revolution clutch, controls, housing. The Hilliard Corp, 100 W Fourth St, Elmira, NY.

(E-86) Overrunning Clutch—Bulletin, 8 pp. Presents dimensions, capacities, details of construction and operation, selection factors. The Hilliard Corp, 100 W Fourth St, Elmira, NY.

(E-87) Electric Clutches—Bulletin, 20 pp. Describes magnetically actuated multi-disc clutches, including stationary field type. Provides selection and application guides. I-T-E Circuit Breaker Co, 1900 Hamilton St, Philadelphia.

(E-88) Gearshift Drives—Bulletin, 8 pp. Tabulates characteristics and makes comparisons with other types of multi-speed drives. The Lima Electric Motor Co, Inc, Findlay Rd, Lima, Ohio.

(E-89) Notched Belts—Brochure, 4 pp. Lists sizes and advantages of positive drive belts. Goodyear Tire & Rubber Co, Akron, Ohio.

(E-90) Stamped Gears—Catalog, 20 pp. Explains terms, tolerances, choice of materials for spur, segments, rack, anti-backlash and other gears. Fastex Div of Ill Tool Works, 195 Algonquin Rd, Des Plaines, Ill.

(E-91) Gear Couplings—Brochure, 16 pp. Provides general descriptions of 24 models such as marine, disconnect, shear-pin and other types. Koppers Co, Inc, 200 Scott St, Baltimore 30.

(E-92) Thin Ball and Roller Bearings—Catalog, 28 pp. Provides dimensions, capacity formulas, life and speed factors. Sizes go from 4 in. bore to 40 in. outer diameter. The Kaydon Engineering Corp, Muskegon, Mich.

(E-93) Thin-shell Needle Bearings—Bulletin, 4 pp. Charts dimensions, capacity. Explains installation and spherical end design of rollers. The Kaydon Engineering Corp, Muskegon, Mich.

(E-94) Variable Speed Pulleys—Catalog, 25 pp. Describes performance characteristics, dimensions for ratings to 25 hp, speed ranges to 10:1. Lewellen Mfg Co, 1428 Tenth St, Columbus, Ind.

(E-95) Variable Speed Transmission—Catalog, 25 pp. Provides illustrations and engineering data for ratings to 60 hp and speed ranges to 20:1. Lewellen Mfg Co, 1428 Tenth St, Columbus, Ind.

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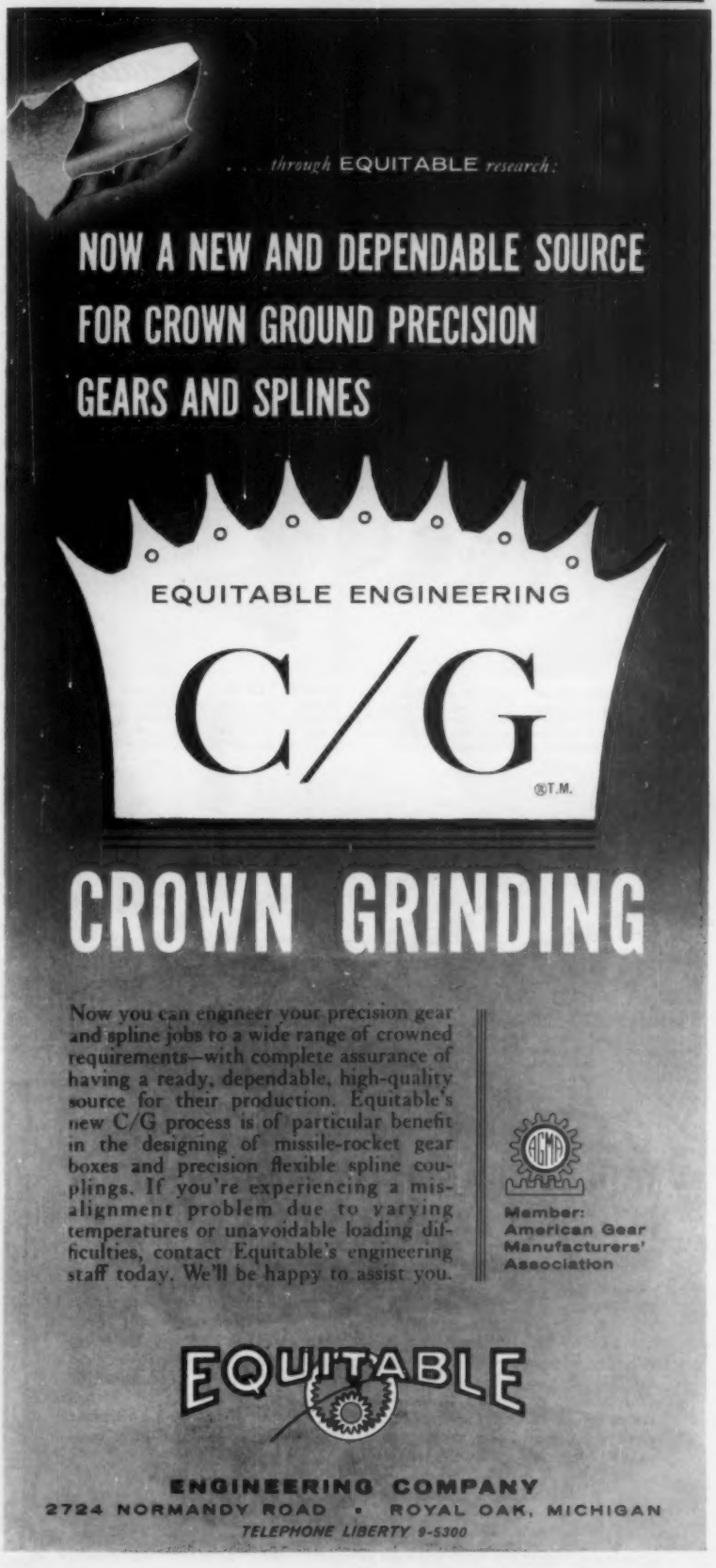
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SPURS..from Spur Gears made from punched blanks to ultra precision cut. Applications include appliances, sewing machines, office machines, instruments.

SPIRAL BEVELS..Gears and Pinions made from alloy steels and hardened. Also, straight and zerol type teeth. Used in outboard motors, portable tools, lawn mowers and cameras.

HELICALS..and Spiral Gears are made of any material . . hardened and polished if required. Used in speed reducers, power tools, diesel engine fuel pump systems, etc.

WORMS..complete facilities for milling, hobbing, grinding and super finish by an *exclusive* G.S. generate-polish. Typical uses: speed reducers, business machines, coin operated phonographs, fans, clippers, military equipment.

WORM GEARS..Laminated Plastic, Bronze, Nylon, Cast Iron, or Steel. Cut in curved and straight face. G.S. *patented grooves* for quietness. Used in valve seat grinders, food mixers, meat slicers, speed reducers, automatic phonos.

ARMATURE SHAFTS..Worms, Spur and Spiral Pinions, as well as Spiral Bevel Pinions cut integral with shafts. Diameters ¼" and up. Used in floor polishers, fans, portable tools, etc. Gear sections hardened as needed.

UNUSUAL FORMS..Clutches, Sprockets, Cams, Segments, Lead Screws, Adjusting Worms. Mass manufactured for chain saws, outboard motors, check protectors, marine steering, telephone answering devices.

SPECIAL COMPONENTS..high precision parts for military and aircraft applications. Serrations, Splines, and Milling are held to close limits with precise tooth alignment.

INTERNALS..cut to exacting specifications up to 6" pitch diameters. Typical applications: air operated hoists, floor machines, radio equipment, navigating instruments.

G.S. MAKES YOUR SMALL GEARING WITH CUSTOM PRECISION, IN PRODUCTION RUNS...AT PRACTICAL COSTS

Whether your needs are numbered in the hundreds or the thousands . . . for any form of Fine or Intermediate Pitch Gearing . . . unmatched G.S. UNIFORMITY gives you greatest freedom from rejects, smoothest assembly, best field performance you'll ever find! G.S. standards are high—and they're backed by the most efficient machinery to be had, first-class design and production engineering, quality control systems which aim at perfection. If you need production runs of Small Gearing from 8 to 120 dp., from ⅛" to 8" diam., send drawings, specifications or a complete description of your project for suggestions, ideas and cost estimates without obligation to you.

SEND FOR G.S. *illustrated folder! See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant view, Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!*

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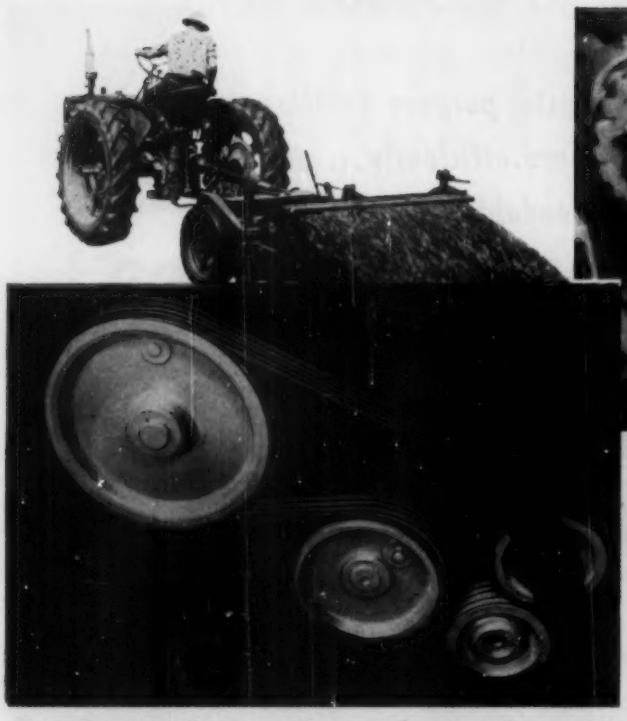
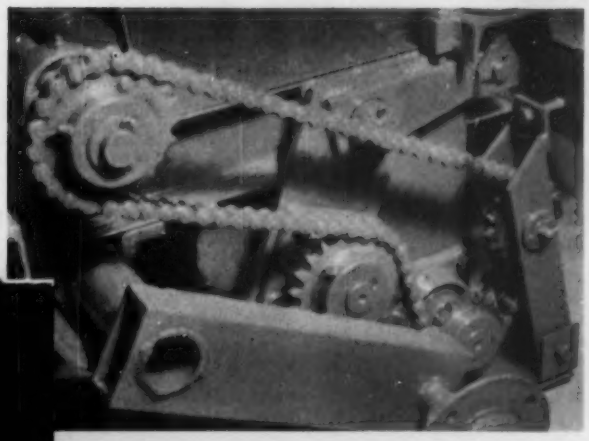
WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARING





FORMER DRIVE: The high speed operation of Gehl's Cure-All Hay Conditioner caused failure of the roller chain drive.

PRESENT DRIVE: Both the limited space and high speed requirements were met with this Gates Super HC V-Belt Drive.

Gehl Brothers Manufacturing Company Finds

Super HC V-Belt Drive handles speeds chain drive couldn't take!

Roller chain drives on Gehl's Cure-All Hay Conditioners **"would not stand up under the speed of operation." Yet conventional V-belts that would fit into the space available could not handle the working load for this outstanding line of forage harvesting equipment.**

The design problem remained a tough one until the introduction of the Gates Super HC High Capacity V-Belt early last year. Then the Gates Field Engineer, working closely with Gehl Engineers designed the new drive shown above.

"The Super HC V-Belt Drive has eliminated need for shear pins and clutches, has increased efficiency, and lowered maintenance costs," is the pleased report from Gehl personnel.

Take advantage of Super HC on your equipment

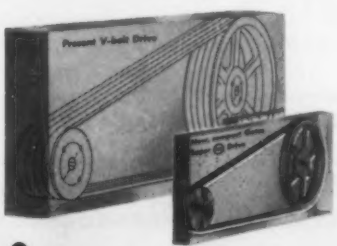
Whenever you have a drive change on a new model or are replacing belts or sheaves, let your Gates Representative show you how Super HC Drives can reduce sheave diameters 30% to 50%, drive space up to 50%, drive weight and cost as much as 20%.

A handbook, "The Modern Way to Design Multiple V-Belt Drives," is yours for the asking. Simply contact your Gates Representative listed in the Yellow Pages.

TPA 505

The Gates Rubber Company, Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates *World's Largest Maker of V-Belts*



Gates Super HC V-Belt Drives

same hp capacity in smaller "package"

CIRCLE 243 ON READER SERVICE CARD 243

For many years the Transmission and Axle Division of Rockwell-Standard has specialized in the design and production of components that help to assure superior performance for special purpose vehicles. We offer manufacturers a complete design, testing and production service. *And we produce and sell only components, not the complete vehicle!*

The component you think "special"—and highly expensive and time-consuming to build—could well be a standard item in Rockwell-Standard's full line of driving assemblies and planetary axles, Hydra-Drives torque converters and power shift transmissions.

If your needs call for a "custom" job, you can be sure Rockwell-Standard engineers can design it to exact specifications—and build it for less. For complete information about Rockwell-Standard's full line of driving assemblies and planetary axles; Hydra-Drives torque converters and power shift transmissions, plus other components for special purpose vehicles write or call today.

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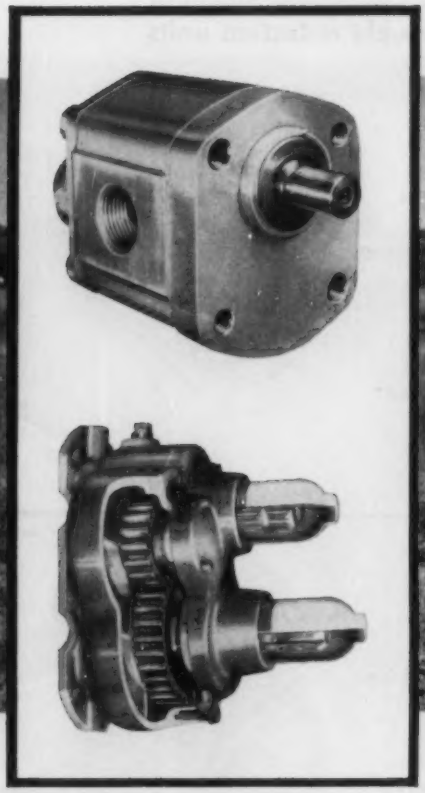
POWER TRANSMISSION

BACK OF BOTH... B-W



In the minds and laboratories of Borg-Warner research engineers are born products that range from implements that till the earth to instruments that probe the universe.

HYDRAULIC

A whole new family of B-W hydraulic gear pumps by Wooster Division engineers have capacities ranging from 0.7 gpm to more than 140 gpm at 2000 rpm and 2000 psi. Unique use of pressure from the outlet port reduces clearance between bearing faces and gears for *optimum volumetric efficiency*. Engineered to meet virtually any specifications—giving you maximum flexibility of design and application. Use Wooster engineers—your major source of hydraulic power transmission requirements.

SERIES P2: Capacity 1.7 to 7.8 gpm at 2000 rpm. Displacement 0.2 to 0.9 cu. in. 2000 psi. Speeds to 4000 rpm.

MECHANICAL

A new B-W dual range power take-off adapter by Warner Automotive Division engineers can be fitted to any tractor, operates farm implements at *either* 540 or 1000 rpm. Saves time and labor . . . up-dates older tractors and up-grades new tractors. Engineered to virtually any rpm requirements for industrial applications. Use Warner engineers—your major source of power transmission gears, gear assemblies, ring gears and pinions, differential parts and assemblies, and spline shafts.

RATED at 30 hp with momentary loads up to 40-50 hp. 6-spline: 540-550 rpm; 21-spline: 985 to 1000 rpm.

For Complete Information Write NOW

WOOSTER DIVISION
BORG-WARNER CORPORATION
Wooster, Ohio

WARNER AUTOMOTIVE DIVISION—**BORG-WARNER CORPORATION**
Auburn, Indiana

Export Sales—**BORG-WARNER INTERNATIONAL**—36 S. Wabash Ave., Chicago 3, Ill.

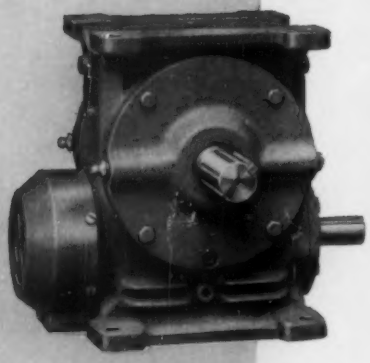
IT'S A BETTER PRODUCT WHEN BORG-WARNER HAS A PART IN IT

DELROYD

WORM GEAR SPEED REDUCERS

FAN COOLED RIBBED CASES

Widest range of ratings available—from .05 HP, 1⅛" center distance to 1050 HP, 36" center distance—in single and double reduction units

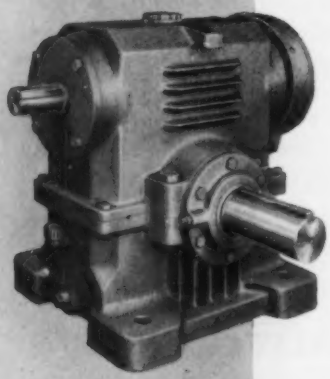


TYPE D
Verso Unit
Adapts to any mounting requirement
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 13.5
Center distance:
2½" to 4"

TYPE V
Vertical single reduction
Shaft up or down
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 150
Center distance:
5" to 12"

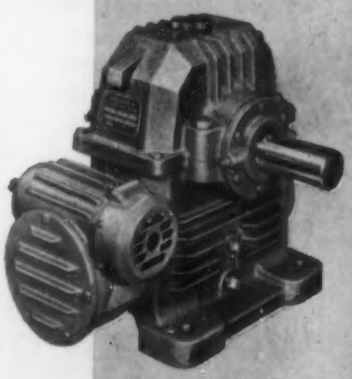
TYPE B
Horizontal single reduction
Bottom drive
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 150
Center distance:
5" to 12"

TYPE HB
Horizontal helical-worm
Right angle drive
Ratios:
15:1 to 355:1
Output torque:
2460 in. lbs. to 135000 in. lbs.
Center distance:
3½" to 12"



TYPE T
Horizontal single reduction
Top drive
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 150
Center distance:
5" to 12"

TYPE DB
Horizontal double-worm
Parallel input and output shafts
Ratios:
75:1 to 4900:1
Output torque:
4170 in. lbs. to 135000 in. lbs.
Center distance:
3½" to 12"



Prompt delivery from stock—all units through 12 inch center distance

DE LAVAL *Steam Turbine Company*

801 NOTTINGHAM WAY, TRENTON 2, N. J.

DELROYD

WORM GEAR SETS

Check these advantages:

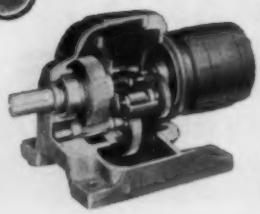
- Involute helicoid thread form (strongest thread form made)
- Centrifugally cast gears
- More horsepower per dollar

Delroyd units are manufactured in a modern plant devoted specifically to the production of worm gearing—a plant which has one of the largest thread milling and thread grinding capacities in the United States. Because we use this exclusive precision machinery, the most exacting testing techniques and highly skilled workmanship, you are assured of quality and service associated with the leading specialists in worm gearing.

Delroyd provides the widest range of sizes and ratios, and offers complete interchangeability of parts. Whether you specify worm gear sets or worm gear speed reducers, you are assured of the finest quality obtainable.

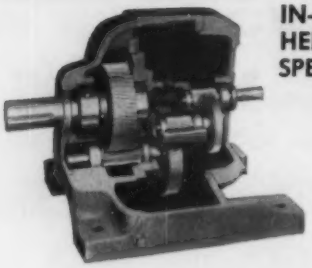
DE LAVAL *Steam Turbine Company*

801 NOTTINGHAM WAY, TRENTON 2, N. J.



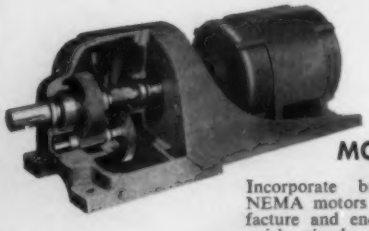
GEARMOTORS

—the ultimate in compactness—maintain positive alignment with flange-mounted NEMA motors. Double, triple and quadruple reductions, sizes up to 100 hp, speeds from 280 down to 1.8 rpm. Send for Book 2747.



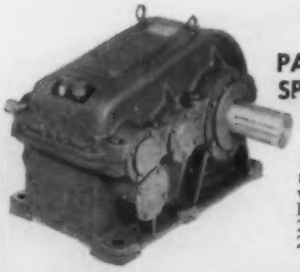
IN-LINE HELICAL GEAR SPEED REDUCERS

let you mount the motor where you want it. Save space with input and output shafts located on same planes. Ratios 6.2:1 to 2217:1, capacities to 206 hp. Send for Book 2751.



MOTOGEARS

Incorporate bracket-mounted NEMA motors of any manufacture and enclosure, permit quick, simple motor replacement. Double, triple and quadruple reductions. Sizes up to 100 hp, ratios from 6:21 to 985:1. Send for Book 2747.



PARALLEL SHAFT SPEED REDUCERS

For high-capacity speed reducing or increasing with heavy shock loads. Ratios to 292:1, up to 2800 hp. Send for Book 2719.

Whatever you need in power transmission . . .

complete

CHAINS AND SPROCKETS

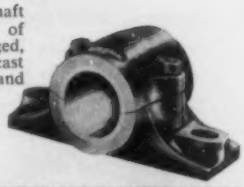
SILENT CHAIN DRIVES — Ideal for large or small hp, large ratios, high speed and limited space. Maintain better than 98% efficiency. Stock sizes up to 50 hp. Ask for Book 2425.

MALLEABLE IRON, PROMAL, STEEL CHAINS — Complete line of cast, combination, forged and fabricated chains plus matching sprockets. Stock sizes. See Book 1050.

PRECISION STEEL ROLLER CHAINS — For drives and conveyors, available in single or multiple widths, in ¼" to 3" pitch and 1" to 3" double pitch. Stock sizes up to 75 hp. Send for Book 2657.

BALL, ROLLER, BABBITTED AND BRONZE BEARINGS

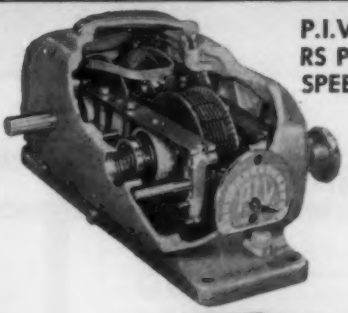
SELF-ALIGNING BALL AND SPHERICAL ROLLER BEARINGS adjust to shaft deflection or misalignment, compensate for normal inaccuracies of mounting. In popular shaft sizes up to 11"—pillow blocks, flanged, flanged-cartridge, cartridge and takeup blocks. Also available in cast and pressed steel housings. Send for Ball Bearing Book 2550 and Spherical Roller Bearing Book 2760.



BABBITTED AND BRONZE BEARINGS —Pillow blocks and flanged blocks are available in 15 different types, solid or split housings, shaft sizes from ½" to 8". Send for Book 2707.

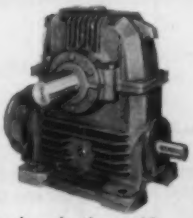
SHAFT-MOUNTED SPEED REDUCERS

Designed to simplify and satisfy the majority of speed reduction jobs. Made in double and triple reductions up to 40 hp. Send for Book 2618.



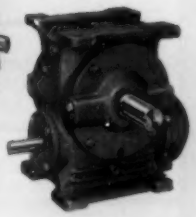
P.I.V. and RS P.I.V. SPEED DRIVES

Stepless, instant variation through a complete range of speeds. 21 types, 9 sizes from ½ to 50 hp and ratios up to 6:1. Send for P.I.V. Book 2274; RS P.I.V. Book 2874.



WORM GEAR SPEED REDUCERS

—for high-ratio speed reduction with right-angle takeoff. Made with single, double or helical worm gear combinations, ratios 3600:1; torque ratings to 135,000 pound inches, up to 150 hp. Send for Book 2824.



UNIVERSAL WORM GEAR SPEED REDUCERS

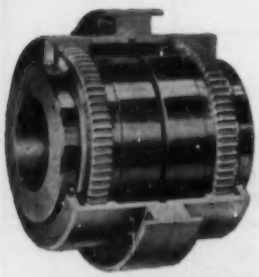
offer 3-way mounting flexibility. Available in 2½-, 3-, 3½-, and 4-in. centers. Sizes up to to 13.5 hp, ratios from 5⅛:1 to 6:1. Book 2724.

FLUID DRIVES

Offer smooth powerful acceleration and operation . . . start heavy loads without excessive power demands . . . protect operating equipment. Available in Fluid, Fluid Gear, Electrofluid Gearmotor and Electrofluid Motogear combinations in single, double, triple and quadruple reductions from 6.2:1 to 985:1 and capacities up to 50 hp. Send for Book 2747.

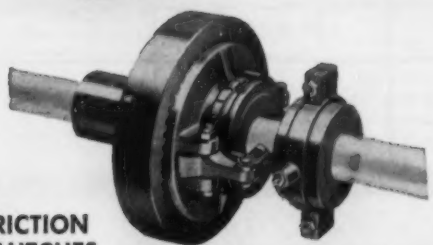
LINK-BELT's complete line gives you

flexibility



COUPLINGS

Flexible, rigid, compression, geared, geared motor, fluid and jaw-clutch types available in shaft sizes from 7/16" up to 12", for light or heavy loads, low or high speeds. Send for RC Flexible Coupling Book 2363; Geared Coupling Book 2775; Geared Motor Coupling Book 2875; All types, Book 1050.



FRICTION CLUTCHES

New design, especially suited where smooth, gradual pickup is a requisite. Available in 3 types with capacities up to 170 hp. Send for Book 2637-A.

FULL FLEXIBILITY is yours when you rely on Link-Belt. Whether you need a single component or a completely engineered drive, Link-Belt can fit your design requirements to a "T."

Link-Belt standards of quality are built into every component—service-proved designs offering longer life . . . efficiency that means *lower-costs*. What's more, pre-integrated designs assure correct mating of all components for smooth-working efficiency—with no elements under- or over-rated.

For complete information and literature, call your nearest Link-Belt office or authorized stock-carrying distributor.

OTHER LINK-BELT PRODUCTS INCLUDE: cut and cast tooth *gears; shaft collars* in solid or split malleable iron and steel types; *backstops* to automatically prevent backward movement of conveyors and elevators; gray iron and die-crown welded steel *pulleys*.

LINK-BELT

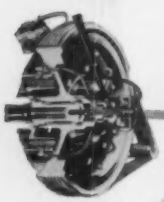
POWER TRANSMISSION MACHINERY

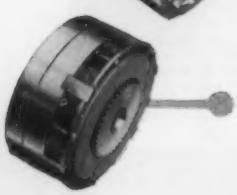
LINK-BELT COMPANY: Executive Offices, Dept. 60-PEDD, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,216-R

FAWICK... for the best

in power transmission components

In the complete FAWICK line you will find a type and size that will fit your requirements for design and high operating performance.



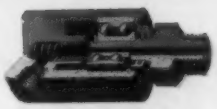


TYPE	SIZE (Friction surface diameter)	TORQUE RATINGS (in. lbs.) (at 75 psi. 100 RPM)	H.P.
CB Clutch & Brake	6" to 84"	2,040 to 1,130,000	3 to 1750
CS Brake	4" to 24"	2,000 to 24,000 plus self energizing	
VC Ventorque Clutch & Brake — Narrow	11" to 42"	27,000 to 380,000	43 to 603
VC Ventorque Clutch & Brake — Wide	24" to 46"	219,000 to 900,000	348 to 1430
E Air Ring Clutch & Brake	12" to 40"	11,300 to 225,000	18 to 357
VE Air Ring Clutch & Brake	19" to 27"	25,500 to 58,500	40 to 93
EB Clutch & Brake	6" to 24"	910 to 45,000	1.5 to 71
ER Couplings	6" to 24"	1540 to 83,500	2.5 to 133
CT Brake	12" to 24"	15,000 to 65,000 plus self energizing	
FSPA (FAWICK Standardized Press Application) — CB Clutch	8" to 36"	4,290 to 172,000	
FSPA (FAWICK Standardized Press Application) — CS Brake	6" to 24"	2,000 to 100,000	
LIQUI-COOL Clutch & Brake		4,500 to 200,000	

MAGNETIC

Applications: Oil or dry operation requiring high speed stops and starts, high cyclic rates, instant starting with heavy loads, or fast engagement and disengagement.

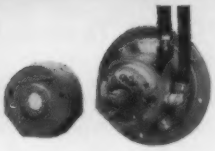
Torque Rating (in.-lbs.)				Body Bore	O.D.	Clutch Diameter
In Oil		Dry				
Start	Run	Start	Run			
27 to 34,000	35 to 44,000	40 to 51,000	50 to 66,000	¼" to 3½"	2⅜" to 13¼"	2" to 13"



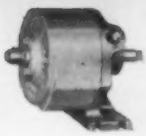
Single Passage Rotorseal

Quick Release Valve

Flexline Clutch Control



Timing Rotorseal



Cam Limit Switch

OPERATION	APPLICATIONS	SPECIAL CHARACTERISTICS	TECH DATA LITERATURE
Pneumatic Actuation Constricting Type	High Speed Cyclic Applications, General Power Transmission	Transmits Torque Through Rubber Side Walls, Complete, Automatic Disengagement, Drum/Friction Shoe Clearance Eliminates Drag, Acts as Clutch Coupling	ML-176-A ML-172 500-A2
Self-Energizing, Spring Engaged — Air Released, Constricting Type	Any Heavy Duty Cyclic Application, Fail-Safe Applications	Automatic Engagement at Any Time of Pneumatic or Electrical Failure — Simple, External Adjustment	ML-99-A ML-161 500-A2
Pneumatic Actuation Constricting Type	Severe Clutch or Brake Duty With High Starting Load or Sustained Slippage	Rapid Heat Dissipation, Low Diametral Size, High Torque Capacity	ML-102-A
Pneumatic Actuation Expanding Type	Medium Speed Cyclic Operation, High Acceleration Loads, Slip Clutch and Tension Brake Applic.	Heavy Duty Construction Resists High Heat Generation	500-A2
Pneumatic Actuation Expanding Type	Slip Clutch Application With Severe Heat Build-Up, Heavy Duty Service	Ventilated Shoe Aids Rapid Heat Dissipation; Relinable in the Field	500-A2
Pneumatic Actuation Expanding Type	Slow Speeds, Moderate Starting Loads, Light Torque for Continuous Slip Service	Transmits Torque Through Rubber Side Walls, Unusually Compact Mounting	500-A2
Pneumatic Actuation Expanding Type	Flexible, Disconnectable Coupling for Engagement at Standstill or Low RPM	Rubber Friction Surface Provides Maximum Torque for Small Diameter	500-A2
Spring Engaged, Air Released, Constricting Type	Extreme Heavy Duty Cyclic Jobs Requiring Exact Stopping	Same Effectiveness in Both Rotational Directions, with Extreme Self-Energization	ML-182
Pneumatic Actuation Constricting Type Self-Energizing, Spring Engaged—Air Released, Constricting Type, Fail-Safe	Power Press Package Application, Also Adaptable to All High Speed Cyclic Machinery Requiring Precise Automatic Control of Single, Continuous or Inching Operations	No Backlash, Simplified Installation, Provides Manpower and Machine Protection, Reduces Flywheel Overhang	ML-172 500-A2
Air, Water or Hydraulic Fluid Actuation	High Inertia Starting & Stopping, Constant Tension Braking, Continuous Slip Clutching, High Rotational Speeds	Large Operating Pressure Range (0-75 psi), Rapid Heat Dissipation, Light Weight, Low Coolant Usage	ML-181

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

FAWICK AIRFLEX

INDUSTRIAL CLUTCHES AND BRAKES

CIRCLE 251 ON READER SERVICE CARD

Flexible Shafts

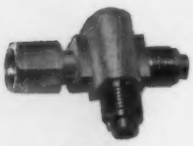
FOR MANY FIELDS

CIRCLE ESS

Circle Ess Flexible Shafts are compact, lightweight, strong, and durable. They transfer power efficiently and economically regardless of obstructions in the path of installation, while insuring the most accurate alignment.

Pictured below are examples of the flexible shaft assembly, and a few of the industries in which flexible shafting has found application. Complete specifications on the cable and casing which make up the flexible shaft assembly are included in our Circle Ess Flexible Shaft booklet. Send for it today.

Rt. Angle Adapter



Dual Drive Adapter

Rt. Angle Ball Bearing Adapter

H Type Adapter

CIRCLE ESS ADAPTERS

are lightweight, compact, durable and offer a number of varied uses. The Dual Drive Adapter pictured here measures only 2-27/32" x 1-61/64" and weighs only 4 oz. For complete adapter specifications send for Flexible Shaft Adapters Catalog.

AIRCRAFT

AUTOMOTIVE

INDUSTRY

MISSILE

ELECTRONICS

ROCKETS

F.W. STEWART CORP.

4311-13 RAVENSWOOD AVENUE · CHICAGO 13, ILL.

WEST COAST PLANT: 2404 So. Grand Ave., LOS ANGELES 7, CALIFORNIA

CIRCLE ESS

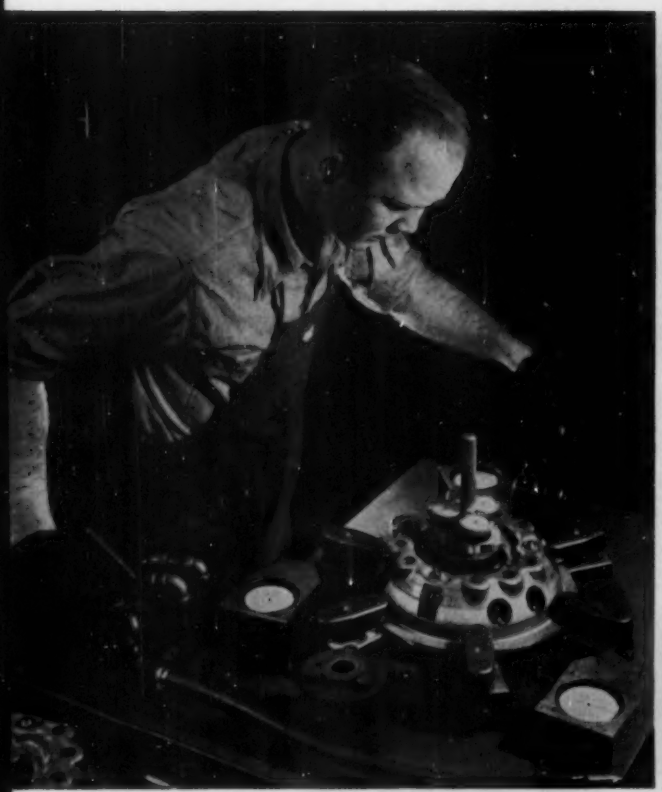
Quality Control is a BORG & BECK tradition that means

BETTER CLUTCHES

At Borg & Beck, quality control is not just a phrase to which we pay lip service. It is a tradition born of the long-standing Borg & Beck policy of building up to a standard —not down to a price.

In the photograph at the left, for example, release levers are being checked on special equipment to make sure they are parallel with the pressure plate. As shown at the right, every Borg & Beck clutch plate is carefully tested for correct deflection to assure positive release. And every driven plate and cover assembly is dynamically balanced for maximum smoothness of operation.

These exacting tests are typical of the extra care that goes into every step in the making of Borg & Beck clutches. They are your assurance of top quality, top performance, top value. And that means: BETTER CLUTCHES.



BORG & BECK CLUTCH THE STANDARD

Reg. U.S. Pat. Off.

BORG & BECK B-W BORG-WARNER

BORG & BECK®

THE AUTOMOTIVE STANDARD FOR MORE THAN 40 YEARS

BORG & BECK DIVISION, BORG-WARNER CORPORATION, CHICAGO 38, ILLINOIS

Export Sales: Borg-Warner International, 36 S. Wabash, Chicago 3

CIRCLE 253 ON READER SERVICE CARD

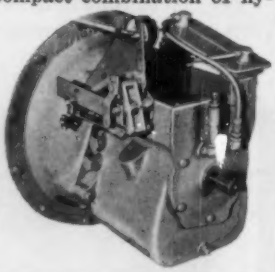
E POWER TRANSMISSION

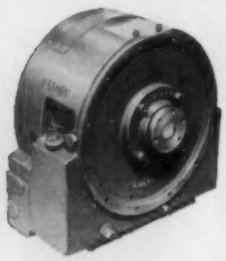
CUSTOM-BUILT Power Transmissions from Standard FUNK Components

FUNK Modular Units can be combined in an unlimited number of power transmission arrangements, quickly and economically — without special engineering costs. Only 3 standard flanges do the trick — fit practically any unit to any machine and any need. You get a custom-made system — at a production-line price. Our engineering department will be glad to work with you.

REVERS-O-MATIC® DRIVES

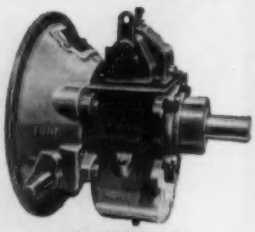
A single throttle lever changes your direction and speed of travel and controls this compact combination of hydraulically operated clutch and torque converter. It's the simplest control yet devised for shuttle movement — up and down — forward and reverse. *Smooth, instant, positive* action — without shock. Standard flanges readily adapt to other components. Ideal for road rollers, hoists and shovels.





TORQUE CONVERTERS

A diversified line of compact short-coupled units. Fit SAE housings. Standard flange system adapts to any other Funk equipment.



REVERSING TRANSMISSIONS

A rugged, synchronized shift for fast reversals. Eliminates bringing machine to a complete stop to change direction. Ideal for loaders, conveyors and winches. Pictured with heavy-duty clutch housing.

RIGHT ANGLE DRIVES

Available in several heavy duty, high torque types. Mount up, down, right or left drives. Easily adapted.

GEAR REDUCTION POWER TAKE-OFFS

4", 4¾" and 6½" gear centers. For 50, 75 and 90 H. P. engines with SAE housings. Wide selection of standard ratios. Equipped with standard modular flanges. Feature exclusive straddle mounted pinion Twin-shaft and single-shaft models.

WRITE FOR CATALOG OF OUR COMPLETE LINE

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Send Us Your Power Transmission Problems

FUNK MFG. CO.

P. O. Box 577-D

Coffeyville, Kansas

254 CIRCLE 254 ON READER SERVICE CARD

manual of Reliability

This handbook of principles is based on a personal study of the reliability departments or divisions in leading companies, on interviews with dozens of men charged with this responsibility, supplemented by a nationwide survey — with emphasis on mechanical reliability—the "facts behind the fad."

Topical headings: what is reliability, what has been done, how to design for reliability, a design check list, human factors in reliability, importance of failure analysis, statistical tools, the reliability organization, implementing the program and importance of communications.

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CIRCLE 632 ON READER SERVICE CARD

catalogs and bulletins.....continued

(E-96) Electric Clutches—Catalog, 20 pp. Dry plates or face teeth are engaged electrically. Tables, curves and formulas give dimensions, torque and thermal ratings. I-T-E Circuit Breaker Co, 1900 Hamilton St, Philadelphia 30.

(E-97) Power Transmission—Catalog, 15 pp. Describes flexible couplings, variable speed pulleys and transmissions, shaft mounted gear reducers and others. Lovejoy Flexible Coupling Co, 4841 W Lake St, Chicago.

(E-98) Belt Power Transmission—Catalog, 32 pp. Provides dimensions and ratings of v-belts, pulleys, sheaves, variable speed transmissions and others. Lovejoy Flexible Coupling Co, 4945-4949 W Lake St, Chicago 44.

(E-99) Large Gears—Bulletin, 12 pp. Outlines capabilities of company for making large and also regular size gears. Example: spur gears to 134 in. PD. Illinois Gear & Machine Co, 2108 N Natchez Ave, Chicago 35.

(E-100) Flexible Couplings—Catalog, 20 pp. Contains drawings, dimensions, load computation tables and graphs. Couplings handle up to 1020 hp. Includes universal joints. Lovejoy Flexible Coupling Co, 4945-4949 W Lake St, Chicago 44.

(E-101) Magnetic Clutches—Brochure, 4 pp. Small 24 vdc clutches handle up to about 24 in.-lbs torque. Curves, tables and drawings give dimensions and operating characteristics. The Magnetec Corp, 7232 Eton Ave, Canoga Park, Cal.

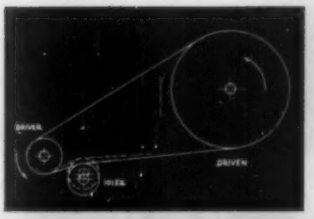
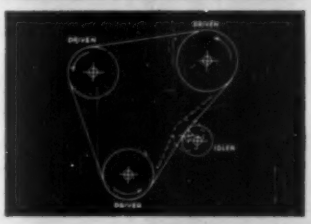
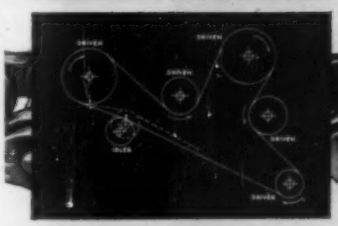
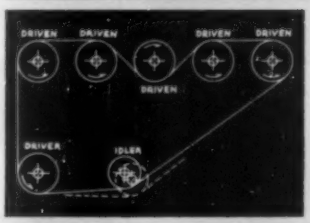
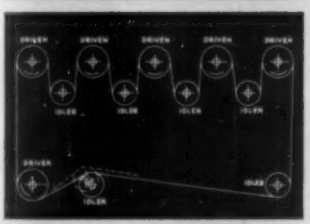
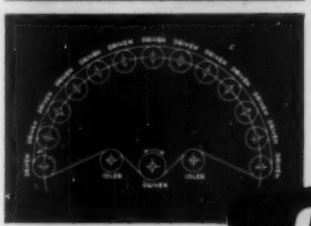
(E-102) Link V-belts—Brochure, 8 pp. Gives rating table and design guides for link belting to replace section D and E v-belts. Manheim Mfg & Belting Co, Manheim, Pa.

(E-103) Link V-belts—Catalog, 24 pp. Furnishes tables and instructions for selecting link belting to replace sections 00 through E v-belts. Manheim Mfg & Belting Co, Manheim, Pa.

(E-104) Clutches—Catalog, 76 pp. Presents dimensioned drawings, capacities, illustrations of applications. Includes automatic freewheeling clutches for single shaft drives; clutch couplings for connecting shaft ends; backstops for conveyor or elevator headshafts; enclosed units for high speed, outdoor, continuous operation. Marland One-Way Clutch Co, Box 308, LaGrange, Ill.

(E-105) Variable Pitch Pulleys—Catalog, 4 pp. Gives dimensions and capacities for spring loaded pulleys, hand wheel controlled compound drives to handle ½ to one hp. Maurey Mfg Corp, 2907-23 S Wabash Ave, Chicago 16.

continued

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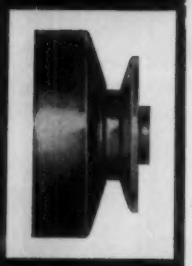

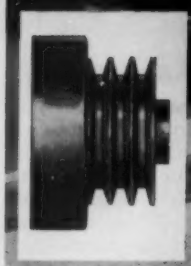

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Cost savings on precision molded, nylon reinforced fiberglas parts can easily amount to one-third — or more. Rampe Variable Pitch Pulleys and Speed Reducers add extra chemical and wear resistance, impact strength, self-lubrication for hard-to-reach installations. Durable, proved in scores of production applications. Fighting high costs? Send for details and prices today.

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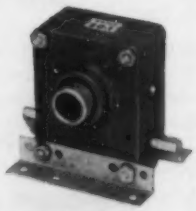

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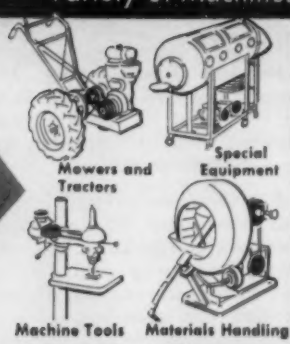

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catalogs and bulletins.....continued

(E-106) **Clutch-sheave**—Brochure, 10 pp. Describes device which combines electric clutch and v-belt sheave to give variable torque output. Warner Electric Brake & Clutch Co, Beloit, Wisc.

(E-107) **Air Clutches**—Bulletin, 4 pp. Expanding air tube engages friction discs. Tables give ratings and dimensions. Wichita Clutch Co, Inc, Box 1150, Wichita Falls, Texas.

(E-108) **Stamped Gears**—Catalog, 8 pp. Lists available stock dies for stamped gears from 8 to 120 diametral pitch. Winzeler Mfg & Tool Co, 7355 W Wilson, Chicago.

(E-109) **Miniature Speed Reducers**—Bulletin, 4 pp. In-line reducers come in 400 ratios from 1 to 1 up to 531441 to 1. Includes anti-backlash model. Speeds of 10,000 rpm possible. Metron Instrument Co, 432 Lincoln St, Denver 3.

(E-110) **Small Speed Reducers**—Bulletin, 4 pp. Spur gear reducers operate at 10,000 rpm maximum, handle 0.1 hp—0.05 hp for anti-backlash model. Over 600 ratios listed. Metron Instrument Co, 432 Lincoln St, Denver 3.

(E-111) **Gears, Speed Reducers**—Catalog, 268 pp. Contains tables, charts, diagrams describing bevel, helical, single and double worm gear reducers; gears, gear hobs, sprockets. Also offers special work. The Ohio Gear Co, 1333 E 179 St, Cleveland.

(E-112) **Servo Drive**—Bulletin, 4 pp. System with servo amplifier, servo valve, hydraulic motor and tachometer-generator gives forward and reverse speed control. Pegasus Laboratories, Inc, 3690 W Eleven Mile Rd, Berkley, Mich.

(E-113) **Precision Gears**—Brochure, 25 pp. Shows types of gears, sprockets, clutches and related products company can make. Lists machinery used. Quaker City Gear Works, Inc, 800 Red Lion Rd, Bethayres, Pa.

(E-114) **Silent Chain**—Catalog, 40 pp. Explains design of drives, operation of chains, installation and maintenance. Tabulates ratings and dimensions of chain and sprockets. Ramsey Products Corp, 55 Broadway, Albany 4, NY.

(E-115) **Ribbed Belts**—Catalog, 12 pp. Ribbed design carries more power than equal width of v-belts. Tables give sizes of belts and sheaves. Raybestos-Manhattan Inc, Manhattan Rubber Div, Passaic, NJ.

(E-116) **Small Ribbed Belts**—Bulletin, 4 pp. Sizes designed for short centers and small sheaves. Provides design formulas and selection tables. Raybestos-Manhattan, Inc, Manhattan Rubber Div, Passaic, NJ.

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Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD 66DD.

DUFF-NORTON COMPANY
Four Gateway Center • Pittsburgh 22, Pa.
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DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

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Ratchet Lever • Air
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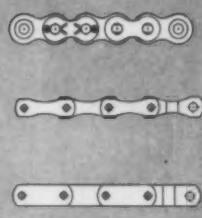
WHITNEY CHAIN DRIVES FOR EVERY NEED

MSL* SELF-LUBRICATING CHAIN

Whitney MSL Self-Lubricating Chain is lubricated for life by oil-impregnated, sintered steel bushings. No additional lubrication is required. Outlasts conventional pre-lubricated chain as much as 5 to 1 in severe operating environments. Completely interchangeable with any A.S.A. Standard chain. Write for Catalog MSLB-2.

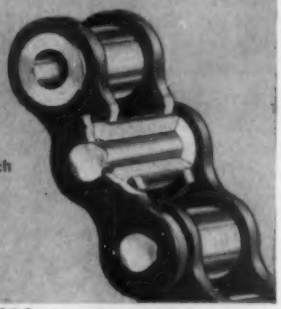
*Maximum Service Life



STANDARD SERIES
¼", ⅜" and ¾" Pitch
Available in single, double and triple strand

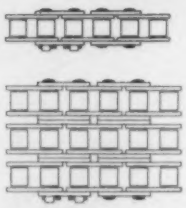
DOUBLE PITCH SERIES
Transmission Type "A"
Available in 1", 1¼" and 1½" Pitch

CONVEYOR TYPE "CA"
Available in 1⅝" and 2" Pitch



AMERICAN STANDARD ROLLER CHAIN

Whitney American Standard Roller Chain Drives are made to exacting specifications from carefully selected materials to provide the user with dependable, low cost drives for any application. Rolls, Bushings, Pins and Plates are designed for long-life operation. Careful assembly into chain of uniform pitch assures quick, easy installation.

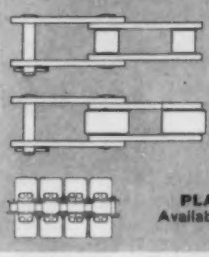


AVAILABLE IN SINGLE STRAND
From ¼" to 3" Pitch in standard and heavy series

AVAILABLE IN MULTIPLE STRANDS
From ⅜" to 3" Pitch in standard and heavy series

CONVEYOR CHAIN

Whitney Conveyor Chain is available in types and sizes to meet a wide range of applications. They are supplied in two types: #2000 Series with standard rollers and the #2002 Series with oversize rollers as illustrated. Both types can be supplied with bent or straight attachment lugs and extended pins. Platform Series Chain is designed for smooth, level operation with no chatter or vibration, even on extended conveyor lines.



STANDARD ROLLER SERIES
Available from 1" to 4" Pitch

LARGE ROLLER SERIES
Available from 1" to 4" Pitch

PLATFORM SERIES
Available in a variety of types

STOCK SPROCKETS

Whitney Stock Sprockets are manufactured to the highest quality standards. Sprocket teeth are correctly designed and accurately cut to A.S.A. Standards for dependable performance and maximum chain life. Types A, B, and C are available in single and multiple pitch widths in a wide range of pitch sizes.

TYPE A—No Hubs

TYPE B—Hub on one side

TYPE C—Hub on both sides

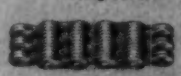
Multiple Strand Sprockets

OTHER CHAIN PRODUCTS

The Whitney Chain line included many standard and special purpose chain drives and chain components. Every Whitney product is years of specialized design and manufacturing experience. Whatever your requirement in chain drives or chain products, there's a Whitney product to meet the need. Write for the Whitney Chain Catalog.

OILFIELD SERVICE CHAIN
Available in standard and heavy series chains up to sextuple strand

FLEXIBLE COUPLINGS
Available with coupling covers



LEAF CHAIN AND BLOCK CHAIN

MINE SERVICE CHAIN
with exclusive Whitney Universal Joint feature on flight conveyor types

THE WHITNEY CHAIN COMPANY

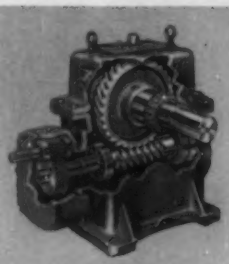
4587 S. Western Blvd., Chicago 9, Ill.

a subsidiary of
FOOTE BROS. GEAR AND MACHINE CORPORATION

From THE ONE COMPLETE LINE of Power Transmission Drives

WORM GEAR DRIVES

- 162 sizes; 17 types
- 1⅛" to 20" Center Distances
- Output Torque to 500,000 lb. in.
- Capacities From .01 to 165 HP



Horizontal Single, Double Reduction

Fan-Cooled

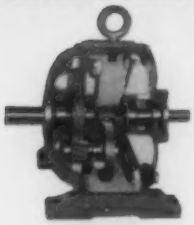
Vertical Single, Double Reduction

Vertical Single, Double Reduction for use with Extended Output Shafts

Foote Bros. Worm Gear Drives combine precision generated worm gearing with balanced design bearings and shafts to deliver economical, dependable right angle power for any application. Drives are rated to AGMA Standards. Write for Catalog HGB.

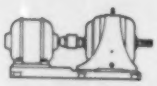
CONCENTRIC SHAFT DRIVES

- 554 Stock Combinations
- Capacities From 1 to 150 HP
- Output Torque to 100,000 lb. in.



Foot Mounted Straight Line

Foot Mounted Right Angle



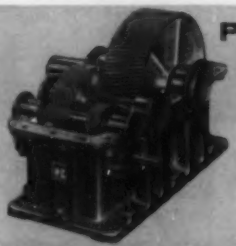
Base Mount

Flange Mounted Straight Line and Right Angle Types

Concentric Shaft Drives incorporate high hardness, premium quality Duti-Rated Lifetime Gearing to provide greater load carrying capacity and longer service life. Compact design takes less space per rated horsepower. Rated to AGMA Standards. Write for Engineering Manual LP No. 3.

PARALLEL SHAFT DRIVES

- 82 Standard Sizes • 9 Shaft Arrangements
- Capacities to 1550 HP



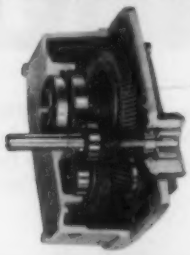
Standard Housing

All Steel Housing

Foote Bros. Parallel Shaft Drives are designed for applications with heavy shock loads, high overhung loads—or installations requiring multiple output shafts. Ruggedly built to deliver trouble-free performance under most severe conditions. Rated to AGMA Standards. Write for Catalog MPB.

SHAFT MOUNTED DRIVES

- 45 Stock Combinations
- Capacities From ¼ to 40 HP
- Output Speeds: 9 to 420 RPM



Single Reduction

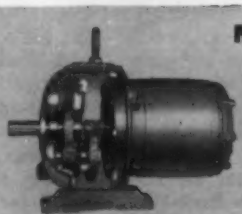
Double Reduction

Flange Mount

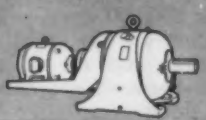
Duti-Rated Lifetime Gearing in Foote Bros. Shaft Mounted Drives transmits more horsepower—size-for-size than any other units to make them more economical, more efficient, in any application. Designed for quick, easy mounting. Rated to AGMA Standards. Write for Catalog SMB.

MOTORIZED DRIVES

- More than 3000 Stock Combinations
- Output Speeds From 7.5 to 780 RPM
- Capacities to 150 HP



Horizontal Gearmotor



Horizontal Line-O-Motor

Vertical Gearmotor

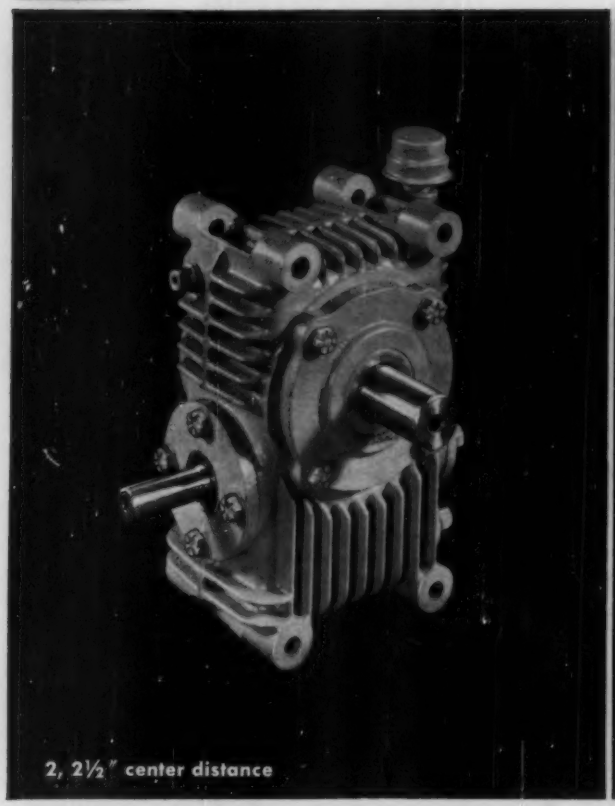
Vertical Line-O-Motor

Stronger, tougher Duti-Rated Gearing in Foote Bros. Motorized Drives guarantees smoother operation, longer life. Foote Bros.—Louis Allis Gearmotors available with any type of motor to meet your needs. Line-O-Motor Drives permit you to use any NEMA Frame motor. Rated to AGMA Standards. Write for Catalog MRA.

FOOTE BROS. GEAR AND MACHINE CORPORATION

POWER TRANSMISSION DRIVES 4567 South Western Boulevard, Chicago 9, Illinois

CIRCLE 259 ON READER SERVICE CARD 259



2, 2½" center distance

3, 3½" center distance

Custom-build Your Worm Gear Drive from . . .

OVER 200,000 STOCK

The four "worm-under" speed reducers shown above represent only eleven sizes of standard, Cone-Drive units. Also standard are 15", 18", 22", and 24" center distance units. Cone-Drive worm gear reducers are available in ratios from 5:1 to 4900:1 and up to over 1200 HP capacity. All units feature the double-enveloping principle in which the worm and gear wrap around each other for greatest tooth contact, strength, smoothness, shock-resistance and quietness of operation.

All Cone-Drive worm-gear reducers feature heavy, ribbed, nickel-iron castings for maximum strength and heat dissipation. Heavy-duty taper roller bearings provide anti-friction support to both worm and gear shafts. Chrome-molybdenum-nickel steel worms and tin bronze gears provide long life and high strength. The Cone-Drive design also gives the exclusive benefit that, in service, both gear and worm tend to regenerate their true form . . . worm and gear wear "in" rather than "out."

Standard Options

By selecting various options, standard units can be obtained to fit almost any drive requirements. By taking advantage of these options in the early design stages, you can often simplify design and improve performance, too. Including size and ratio ranges and options available, Cone-Drive Gears offers over 200,000 worm-gear speed reducer combinations that are standard, shelf-hardware items. Special sizes and ratios can be furnished on a quotation basis. Write for Bulletin CD-218 for complete details.

CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

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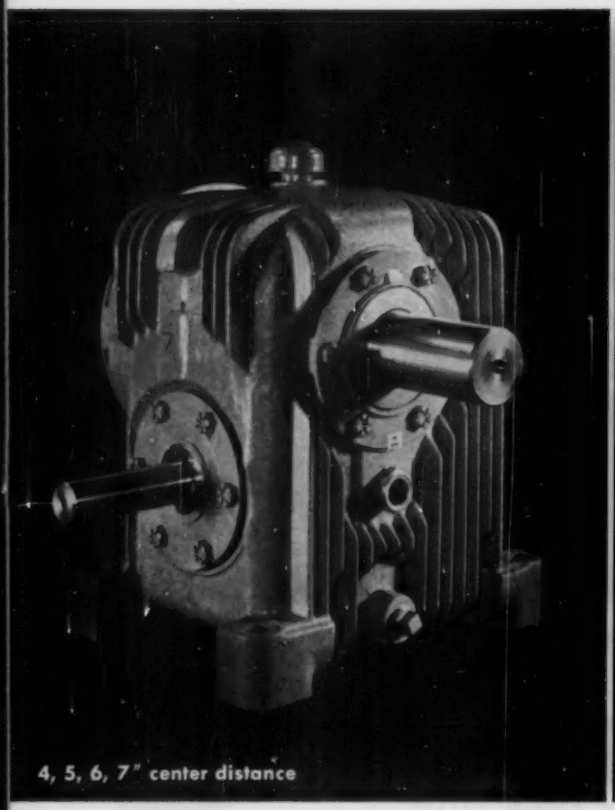
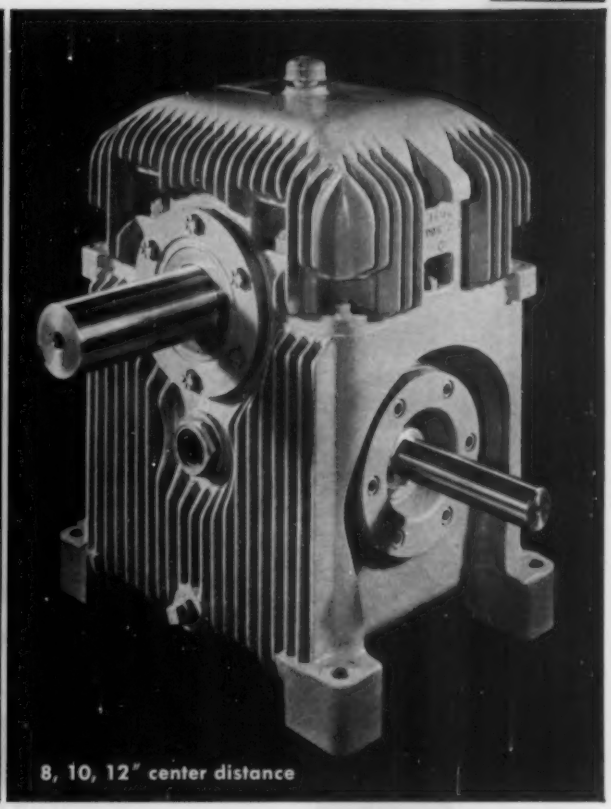
DOUBLE-ENVELOPING WORM GEARSETS

DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

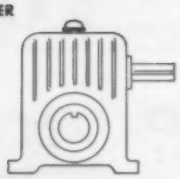
DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS


4, 5, 6, 7″ center distance

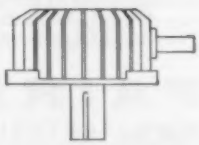

8, 10, 12″ center distance

CONE-DRIVE REDUCERS

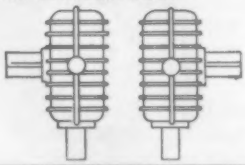
WORM-OVER



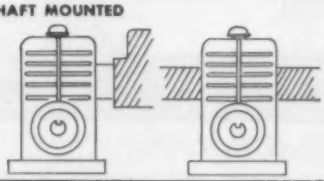
VERTICAL GEARSHAFT



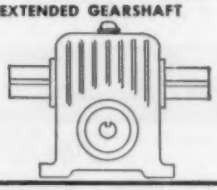
RIGHT- OR LEFT-HAND SHAFT



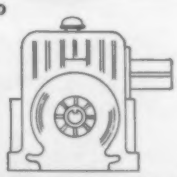
SHAFT MOUNTED



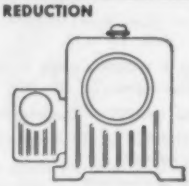
DOUBLE-EXTENDED GEARSHAFT



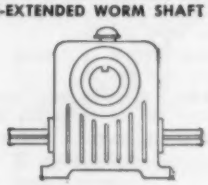
FAN-COOLED



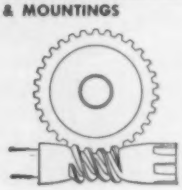
DOUBLE REDUCTION



DOUBLE-EXTENDED WORM SHAFT



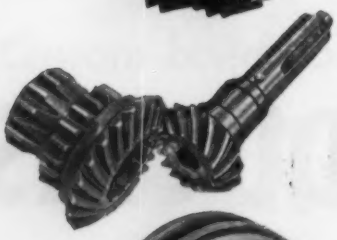
GEARSETS & MOUNTINGS



CIRCLE 261 ON READER SERVICE CARD 261

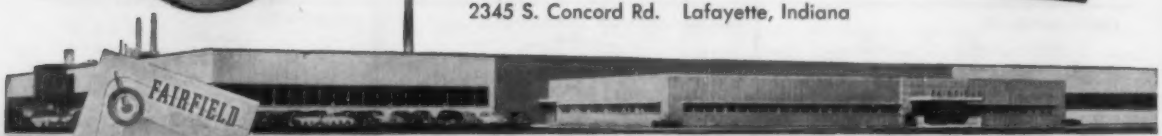
GEARS

—produced to meet your specifications EFFICIENTLY, ECONOMICALLY!



1. **MASS PRODUCTION ECONOMY**—Large or small, you get the benefits of high production rates and big volume output at Fairfield—where fine gears are produced to meet your specifications EFFICIENTLY, ECONOMICALLY!
2. **QUALITY PLUS**—There is no finer recommendation for the quality of the product you sell than to be able to say it is "EQUIPPED WITH FAIRFIELD GEARS!"
3. **DEPENDABLE SOURCE OF SUPPLY**—Fairfield is one of America's largest independent producers of precision-made, automotive type gears for leading builders of construction, agricultural, industrial, marine, and automotive equipment.
4. **BACKED BY EXPERIENCE**—Unexcelled facilities in an ultramodern plant backed by more than thirty-nine years' experience in producing Spur, Herringbone, Spiral Bevel, Straight Bevel, Hypoid, Zerol, Worms and Worm Gears, Splined Shafts, and Differentials to customer's specifications.
5. **ENGINEERING SERVICE**—Fairfield engineers are qualified to make expert recommendations on your gear production requirements. *Your inquiry will receive prompt attention.*

FAIRFIELD
MANUFACTURING CO., INC.
2345 S. Concord Rd. Lafayette, Indiana



ASK FOR INTERESTING ILLUSTRATED BULLETIN

Fine Gears Made to Order

SPUR GEARS — Straight, helical, and internal. Sizes from 16 pitch, 1½" dia., to 1½ pitch, 36" dia.

HERRINGBONE — (Fellows Type). Sizes from 1½" to 15".

SPIRAL BEVEL — Sizes from 16 pitch, 11½" dia. to 1½ pitch, 28" dia.

STRAIGHT BEVEL — Sizes from 16 pitch, 1½" dia. to 1½ pitch, 28" dia.

HYPOID — Sizes from 1½" to 28" dia.

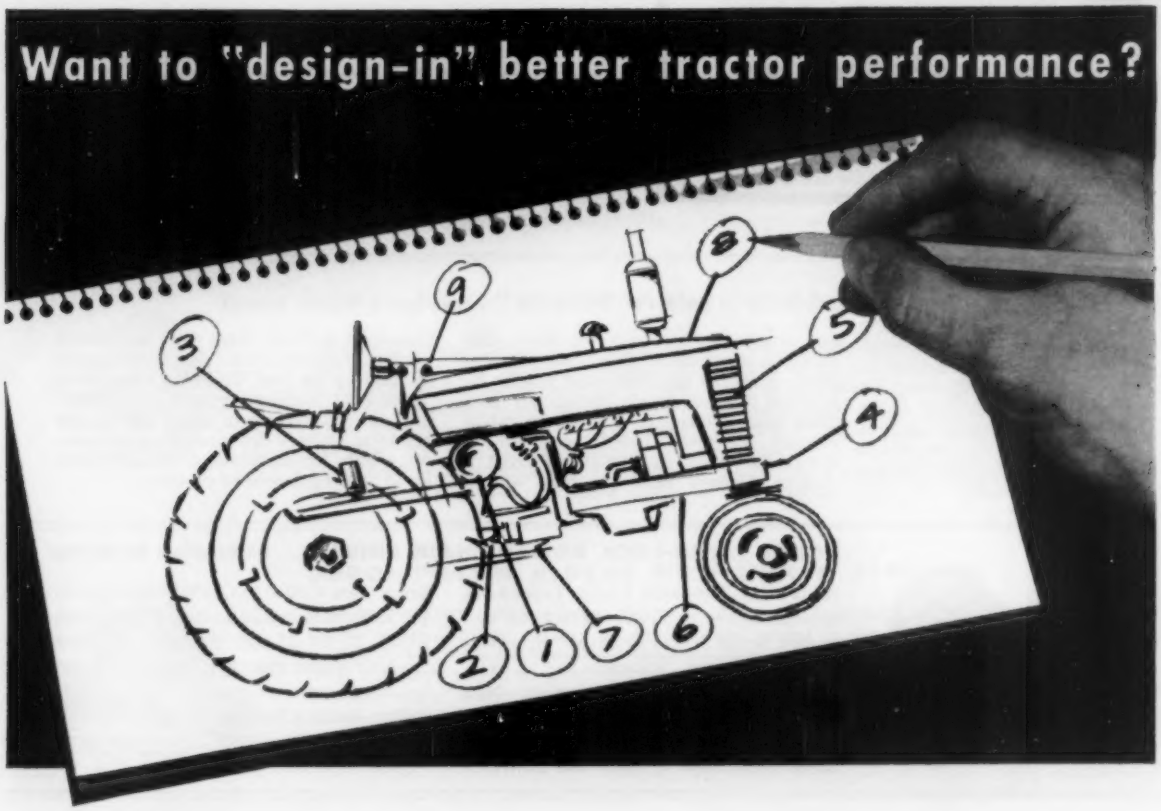
ZEROL — Sizes from 16 pitch, 1½" dia., to 1½ pitch, 21" dia.

WORMS & WORM GEARS — Worms to 7" dia. Worm gears to 36" dia.

SPLINED SHAFTS — Lengths to 72".

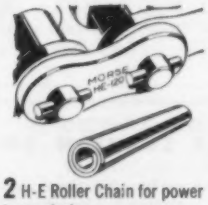
DIFFERENTIALS — 3,000 to 500,000 inch pounds capacity.

Note: All of the sizes above are approximate

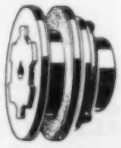


First—check these Morse power transmission components to solve many design problems!

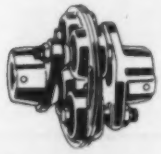
1 Taper-lock sprockets on side power-take-off shaft



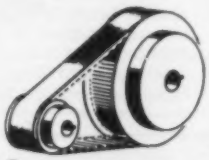
2 H-E Roller Chain for power transmission



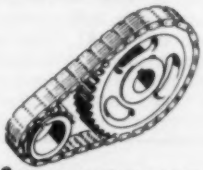
3 Morse torque limiter on power-take-off shaft



4 Morflex coupling on front-end drive shaft take-off

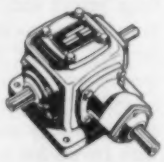


5 Timing® Belt drives for fuel injection application

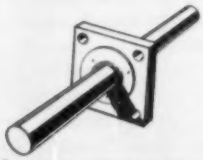


6 Morse silent Timing Chains for tractor engines

7 Hy-Vo® Drives for drop-box transmission



8 Miter boxes for pto drives for saws or grinding wheels



9 Two-Way, No-Way Clutch for hand throttles

Morse power transmission components have wide proved-in-the-field application superiority. By designing them into your tractor or farm machinery, you can simplify and cut many hours off design problems . . . even lower production costs.

Examine these examples of Morse "exclusives". Then call in a Morse engineer to work with you from the start. His broad experience can be a valuable shortcut to a better product for you. Call or write: Morse Chain Company, Dept. 34-90, A Borg-Warner Industry, Ithaca, N. Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario.

MORSE BW T.M.

A BORG-WARNER INDUSTRY

CIRCLE 263 ON READER SERVICE CARD 263

DODGE
of Mishawaka, Ind.

DODGE MANUFACTURING CORPORATION

8900 Union Street, Mishawaka, Indiana

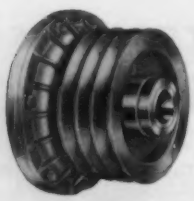
Specialists in Power Transmission Machinery for 80 Years

DODGE DYNA-V DRIVES . . . Save Space, Weight, Money!

An entirely new line of V-belt drives that transmit more horsepower, require less space, generally *cost less*—and handle up to three times as much horsepower in a given space. Narrower grooves, to match stronger, narrower Dyna-V belts, greatly reduce the width and weight of Dyna-V sheaves. Dyna-V belts are built with a crowned top which keeps the Flex-Bonded cords in alignment so that they share equally in carrying the load. Dyna-V sheaves have Taper-Lock bushings for quick, sure mounting—interchangeable in other Taper-Lock products. Dyna-V drives are stocked in two belt widths for capacities to 200 hp. Drives up to 1500 hp furnished on order.

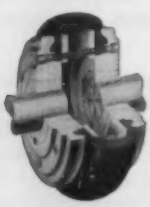
DODGE TAPER-LOCK ROLLER CHAIN DRIVES . . . No Reboring! No Waiting!

All to ASA Standards. Dodge Taper-Lock sprockets are *modern*—save time and money. Single Strand Chain and Sprockets—Nos. 35 to 160. Sprockets to 112 teeth. Double Strand Chain and Sprockets—Nos. 35-2 to 80-2. Sprockets to 112 teeth. Double Pitch Chain and Sprockets—Transmission Series (Nos. 2040 to 2080) and Conveyor Series (Nos. C2040 to C2100). Sprockets to 112 teeth, with *special double pitch design* in 17, 19, 21, 23, 25 and 35 teeth sizes—sizes in which special spacing is required for perfect tooth action. Conveyor Series, Large Roller—Nos. C2042 to C2102. Standard Attachments. Steel Plate Type A Sprockets—Nos. 35 to 120.



DODGE FLEXIDYNE "DRY FLUID" DRIVES

Flexidyne is the surest way to start loads *smoothly*—to protect against damaging overload—*without any sacrifice of efficiency at full load!* It is a "dry fluid" drive that uses heat-treated steel shot as a "flow charge." Initial slippage is momentary. Housing and rotor become locked together by the flow charge and full load is achieved without slip and at 100% efficiency. Flexidyne's "soft start" eliminates the need for oversize or high torque motors. Equipment lasts longer. And big savings are possible in the processing of materials that readily break. Eight drives, ten couplings—fractional to 1000 hp—available from stock. Larger sizes furnished to order.



DODGE PARA-FLEX FLEXIBLE CUSHION COUPLINGS

Here is a new type of performance made possible by the development of a reinforced rubber flexing element. The "4-way flex" of these unique couplings automatically compensates for end-float, parallel misalignment, angular misalignment *or any combination of all three*. It cushions the stresses of shock loads. And it absorbs torsional vibration—reducing noise and protecting machinery.

Para-flexes take minimum space on the shaft. Mounting is simplified through the use of standard Taper-Lock Bushings. Standard type available in capacities up to 2000 hp. Also High Speed and Flywheel types for speeds to 5230 rpm.

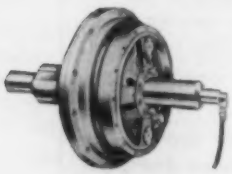
DODGE TAPER-LOCK COUPLINGS . . . Chain, Rigid, Flexible

Ready for the shaft without reboring or machining. Bushings are interchangeable in Taper-Lock products.

Dodge Flexible Disc Couplings are available from stock in shaft sizes from ½″ to 3″. Dodge Rigid Couplings from ½″ to 6″. Dodge Taper-Lock Chain Couplings from ½″ to 3″. Dodge Taper-Lock Chain Couplings permit sufficient movement between hubs to accommodate common minor angular and parallel shaft misalignment. The double width chain and extra teeth give additional bearing area for higher horsepower ratings and longer life. Available with covers for safety, dirt protection and lubrication.

DODGE TORQUE-ARM SPEED REDUCERS . . . Quality, High Efficiency!

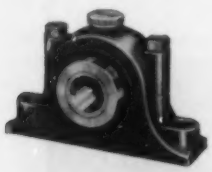
America's most complete line of shaft mounted speed reducers—57 models. Capacities from 1 to 170 hp. Output speeds from 10 to 400 rpm. Single or double reduction. Ratios of 5:1, 15:1 and 25:1. Speed ratios up to 175:1 with correct selection of speed reducer and V-belt drive. Rugged, corrosion-resistant, semisteel housings. Rigid, widely spaced seats for anti-friction bearings. Heat treated, helical steel gears. Modern double-lip seals. Vertical or horizontal mounting. Reducer locks to shaft on *both* sides of housing. Holes in the output hub provide simple removal with puller. Overload release and built-in backstop are optional.



DODGE AIR-GRIP CLUTCHES . . . Instant Response!

Maximum torque capacity in minimum space is provided by these fast, responsive air clutches. Full sensitivity of control from "inching" to complete engagement. Operate at air pressures up to 140 psi—with minimum air volume. Quick-release air valves built into the clutch are available as optional equipment for operations requiring instant disengagement. Air seal disc is located at the end farthest from the pressure plates, which generate the heat inherent in clutch action. Internally ventilated for cooler operation and longer life.

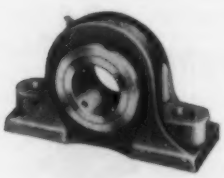
Available from stock in single and double plate types. Capacities from 8.5 to 460 hp at 100 rpm at 80 psi.



DODGE PILLOW BLOCKS WITH TIMKEN BEARINGS

America's *quality* pillow blocks—for extreme dependability of service, from general power transmission needs to industry's heaviest, toughest jobs. Genuine Timken Tapered Roller Bearings give these pillow blocks their high radial and thrust load carrying capacities. Rugged. Precision built. Self-aligning. Easy to mount and demount. Assembled, lubricated, adjusted and *sealed* at the factory—ready for the shaft and for years of trouble-free, economical performance.

Available from stock in five types—Type E, Double Interlock, Type C, Special Duty and All-Steel. Shaft sizes, $1\frac{3}{16}$" to 12". Expansion and non-expansion.



DODGE BALL BEARING PILLOW BLOCKS—SC AND SCM

The SC and SCM ball bearing pillow blocks have been developed to provide—at low cost—high quality, anti-friction bearing service for small shafts and moderate loads.

They are assembled, lubricated and *sealed* at the factory . . . ready for the shaft. Precision built throughout, they feature deep groove ball bearings for high radial and thrust capacity. Long inner race distributes load over greater shaft area. Metal backed synthetic seals that can't blow. Rugged one-piece semisteel outer housing. Fully self-aligning.

SC pillow blocks for normal duty on $\frac{1}{2}$" to $2\frac{7}{16}$" shafts. SCM pillow blocks for medium duty on $1\frac{7}{16}$" to $3\frac{1}{2}$" shafts.

DODGE BRONZE BUSHED BEARINGS . . . with Replaceable Liners!

The bearings with the liners that can be replaced on the job without removing the shaft or bearing base. Costly downtime and disassembly of equipment are eliminated. Three types: Split Bronze Bushed Journal Bearings—$1^{15}/_{16}$" to $2^{15}/_{16}$", Rigid Bronze Bushed Pillow Blocks—$3\frac{1}{16}$" to 8", Angle Bronze Bushed Pillow Blocks—$1^{15}/_{16}$" to 8". Especially suited for heavy loads, high temperatures and corrosive conditions. Dodge also makes Babbitted Solid and Split Journal Bearings, Heavy Rigid Pillow Blocks and Angle Pillow Blocks; Flange Bearings; Fan and Blower Bearings, including the famous Sleevoil Pillow Blocks (plain and water-cooled); and Bronzoil Pillow Blocks.

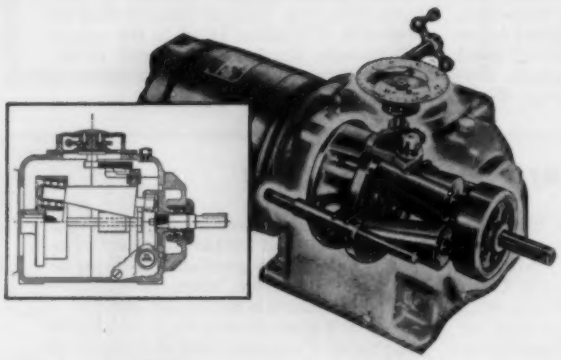
CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Equipment."

DODGE
of Mishawaka, Ind.

CIRCLE 265 ON READER SERVICE CARD 265

E POWER TRANSMISSION

INFINITE RANGE EXTREME ACCURACY...



Get Both... WITH *Graham* VARIABLE SPEED DRIVES

The Graham Drive gives extreme accuracy of speed holding and reset from any desired top speed to zero. Range and accuracy are assured through the correct application of metallic traction in the first stage of a compound planetary system.

Three planet roller cones are canted in a carrier to tractionally engage an encircling control ring . . . Pinions on the large ends of the rollers mesh with a ring gear joined to the output shaft . . . Speed is changeable running or stationary . . . Planetary action provides overload protection. The dial permits settings to one part in 4000.

A wide choice of built-in motors, reducers and controls is available in sizes-fractional to 3 HP. Write for full performance data.

GRAHAM EXTRA FEATURES

- **Any desired maximum speed to zero, including reverse.**
- **Straight line extension of a standard motor for true compactness.**
- **Wide choice of controls; mechanical, pneumatic or electric, provide remote or automatic control of tension, proportion, synchronization, etc., from any type of control signal—3 to 15 psi, 0.5 to 5 ma.**

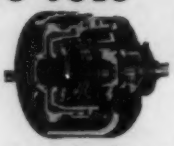
Ask for Graham Catalog 550.

Graham TRANSMISSIONS, INC.
Menomonee Falls, Wisconsin

266 CIRCLE 266 ON READER SERVICE CARD

ONE ENGINE DOES TWO JOBS

when you use a Vari DRAULIC Drive



Whenever an engine has to do two things—operate one work load at constant speed, and another one at variable speed—you need a Vari-DRAULIC.

It is positively and infinitely variable in torque and speed, a shock-free speed control between power source and work load.

Vari DRAULIC
Write or phone for detailed information.

HYDRAULICS, Inc.
1831 SOUTH BOULEVARD
PARSONS, KANSAS

CIRCLE 635 ON READER SERVICE CARD

SIMPLIFY YOUR RIGHT ANGLE POWER TRANSMISSION PROBLEMS . . .

YOUR DESIGN **DESERVES** THE CROWN GEAR "PACKAGE":

• Totally enclosed Aluminum Alloy Housing • 316 Stainless Steel Shafts • Double Sealed Ball Bearings • Hardened Steel, Spiral Bevel Gears • Choice of 4 or 5 Mounting Positions • Ratings from ¼ through 2 H.P. • 1:1 or 2:1 Ratio optional

Contact your local distributor or write direct for new catalog . . .

CROWN GEAR
96 PARK AVE., WORCESTER 10, MASS.
A Division of Harrington & Richardson, Inc.

CIRCLE 636 ON READER SERVICE CARD

catalogs and bulletins.....continued

(E-117) Molded Belts—Bulletin, 4 pp. V-belt made for small sheaves, short centers and high speeds. Gives sizes and motor-to-belt matching table. Raybestos-Manhattan, Inc, Manhattan Rubber Div, Passaic, NJ.

(E-118) Fhp Variable Speed Drive—Catalog, 16 pp. Explains operation, provides dimensions and ratings of stepless drives to ¾ hp. The Zero-Max Co, 1900 Lyndale Ave S, Minneapolis 5, Minn.

(E-119) V-belt Pulleys—Brochure, 8 pp. Presents dimensions of single-groove, fixed bore and pitch pressed steel pulleys. Salem Stamping & Mfg Co, Inc, 631 W State St, Salem, Ohio.

(E-120) Automatic Clutches and Transmissions—Brochure, 4 pp. Describes automatic clutches for gasoline engines from 1 to 6 hp, automatic variable speed torque converters for 1 to 10 hp engines. Salsbury Corp, 1161 E Florence Ave, Los Angeles.

(E-121) Miniature Chains and Sprockets—Brochure, 8 pp. Chain with a 0.1475 in. pitch is used in instruments, controls. Sierra Engineering Co, R A Hawks Div, 123 E Montecito Ave, Sierra Madre, Cal.

(E-122) V-belt Computer—Bulletin, 4 pp. Charts give pulley sizes, shaft speeds, shaft center distances and belt lengths plus output speeds for different pulley combinations. Congress Drives Div, Tann Corp, 3750 E Outer Dr, Detroit 34.

(E-123) Flexible Couplings—Catalog, 48 pp. Gives dimensions, rating tables for flexible disc couplings ranging from ½ in. OD to those suitable for ore crushers and other extreme duty. Thomas Flexible Coupling Co, Box 600, Warren, Pa.

(E-124) Lubricating Devices—Catalog, 9 pp. Provides descriptions, capacities, dimensions of mist coolant systems, chain oilers and other lubricating systems. Price lists are included. Trico Fuse Mfg Co, 2948 N Fifth St, Milwaukee 12, Wisc

(E-125) Sprockets and Chains—Catalog, 80 pp. Contains tables of sizes, dimensions and prices and a good engineering data section. Union Gear & Sprocket Corp, 111 Penn St, Quincy 69, Mass.

(E-126) Gears, Flexible Couplings, Universals, Collars—Catalog, 48 pp. Contains tables of gear sizes and dimensions and a good gear engineering data section. Union Gear & Sprocket Corp, 111 Penn St, Quincy, Mass.

(E-127) Pump Drive—Bulletin, 8 pp. Describes some design features of right-angle drive for vertical pumps. Ratings range from 15 to 150 hp. US Electrical Motors, Inc, Box 2058 Terminal Annex, Los Angeles 54.

continued

FRICTION-FREE MOTION: Recirculating way bearings and ball screws provide mechanical advantages for supporting and moving machine components. TYCHOWAY bearing combines rigidity and capacity of rollers with compact, easy-to-install recirculating feature. Eliminates stick-slip as low coefficient of friction—less than .005—equalizes starting and moving friction. 25 lb force smoothly moves 5,000-lb load even at low speed. Center guide flange assures accurate roller alignment. Antifriction characteristics minimize lubrication problems. SUPER-CISION ball screw combines advantages of screw and nut with antifriction characteristics—mechanical efficiency of 90% or more. Clean, compact nut is result of patented internal ball return. Twin-nuts' unique vernier adjustment (see cut) permits precise preload setting, eliminates backlash. Ball screws and nut housings made to any configuration to suit requirements. These companion products make linear motion completely predictable and accurate, with minimum effort.

Write for Bulletin 22-50

Write for Bulletin 25-50

Special Products Division
Scully-Jones and Company
1928 South Rockwell Street, Chicago 8, Illinois

SCULLY JONES

CIRCLE 267 ON READER SERVICE CARD 267

FOR Optimum positioning control
Minimum break-away friction
System stiffness
Long life without adjustment

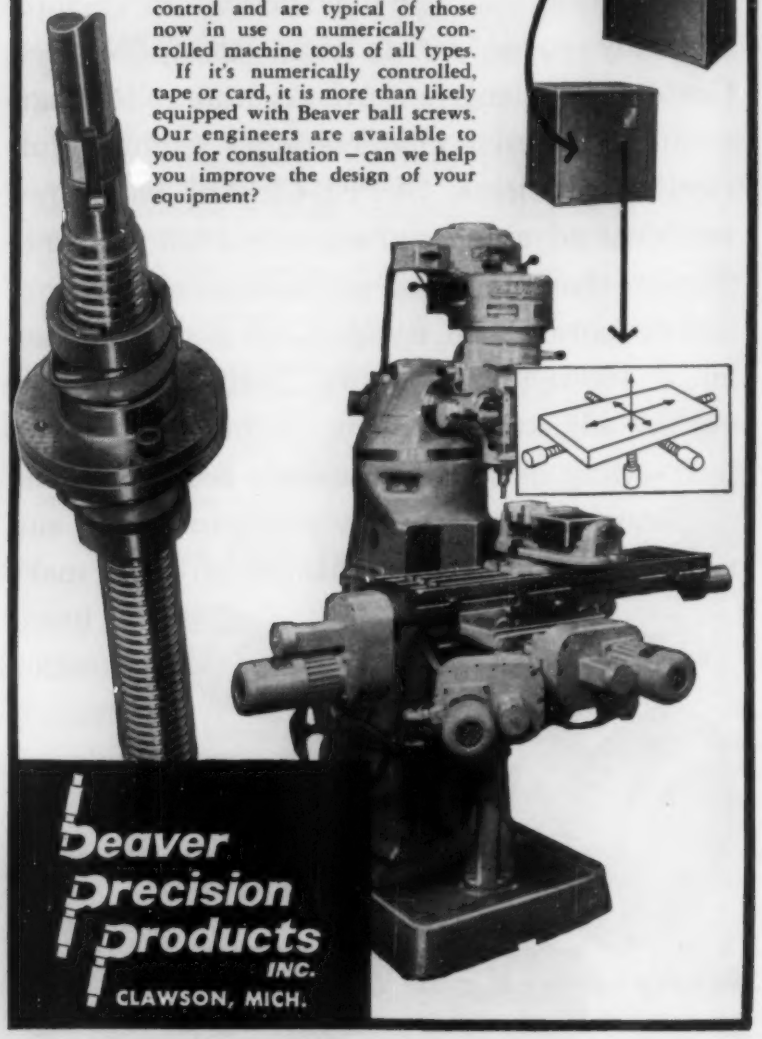
ENGINEERS SPECIFY

BEAVER PRECISION BALL SCREWS

Beaver Precision ball lead screws on all three axes provide the basic measuring and actuating elements which simplify the design of this tape controlled milling machine.

Beaver ball screws move table of this Bridgeport Mill in response to signals from the Electronic Control Systems, Inc. "Digimatic" control and are typical of those now in use on numerically controlled machine tools of all types.

If it's numerically controlled, tape or card, it is more than likely equipped with Beaver ball screws. Our engineers are available to you for consultation – can we help you improve the design of your equipment?



Beaver Precision Products INC.
CLAWSON, MICH.

catalogs and bulletins.....continued

(E-128) **V-belt Drives**—Catalog, 46 pp. Tables of dimensions and capacities provided for pulleys, solid and link belting, refrigeration fans, bushings, accessories. Includes table and guides for choosing correct ratings. Maurey Mfg Corp, 2907-23 S Wabash Ave, Chicago 16.

(E-129) **V-Belts**—Catalog, 24 pp. Offers data on types such as small pulley drives, shock load, notched, link, open end, double-v section v-belts, and positive drive belts. Maurey Mfg Corp, 2907-23 S Wabash Ave, Chicago 16.

(E 130) **Variable Speed Transmissions**—Catalog, 12 pp. Gives dimensions and capacities of drives based on variable pitch v-belt pulleys. Capacities to 5 hp; ratios to 10:1. Maurey Mfg Corp, 2907-23 S Wabash Ave, Chicago 16.

(E-131) **Screw and Nut Device**—Brochure, 11 pp. Explains operating principles and applications of device which performs screw and nut functions plus freewheeling and other special actions. The Anderson Co, Roton Products Div, 1075 Grant St, Gary 40, Ind.

(E-132) **Gears**—Brochure, 4 pp. Presents facilities for making all kinds of gears and sprockets. Lists maximum sizes company can make. E B Sewall Mfg Co, 705 Raymond Ave, St Paul, Minn.

(E-133) **Variable Speed Belt**—Brochure, 5 pp. Shows how this link belt assembles to any length in short time. Enclosed table lists sizes. Manheim Mfg & Belting Co, Manheim, Pa.

(E-134) **Flexible Shafting**—Catalog, 8 pp. Tells how to select casing, ferrules and core of power transmission flexible shafting. Maximum load for largest sized core is 10 lb-in. Tables list sizes, operating speeds, horsepower and torque plus other data. B W Elliott Mfg Co, Inc, 216 Prospect Ave, Binghamton, NY.

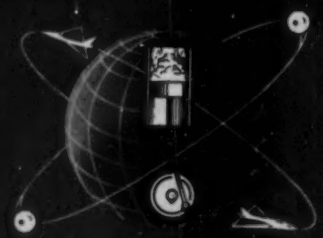
(E-135) **Transmission**—Brochure, 4 pp. Describes a package transmission providing two speeds forward, neutral and reverse. Maximum torque capacity is 1000 in.-lbs. Uses constant mesh planetary gears. The Snow-Nabstedt Gear Corp, 251 Welton St, Hamden, Conn.

(E-136) **Clutches**—Brochure, 4 pp. Shows a variety of clutches, clutch-brakes and brakes. Includes disc, shoe, air operated and other types. Lists data necessary for proper selection. Industrial Clutch Corp, Waukesha, Wisc.

(E-137) **Miniature Clutches**—Catalog, 6 pp. Gives engineering and construction data, sizes and prices for stock units with nonreversing, overrunning, single revolution and indexing, applications. Precision Specialties, Inc, 1342 E 58 St, Kansas City, Mo.

SECTION F

MECHANICAL PARTS AND DESIGN ANALYSIS



Design Abstracts 270

Design Curves for Journal Bearings
by Donald F Hayes 272

New Concepts on Safety Factors
by Charles Lipson 275

Which Bearing and Why?
by Arnold O. DeHart 279

Moment of Inertia of Cylinders 285

Design Equations for Curved Springs
by Joachim Palm and Klaus Thomas 286

Designing Products for Automatic Assembly
by Robert L. Esken 288

DESIGN ABSTRACTS

REDUCTION OF STATIC FRICTION

In position-control servomechanisms operating at creep speeds, the presence of friction often results in undesirable effects such as operating dead zone, low frequency wander, and poor dynamic performance for low level signals. Frictional relaxation oscillations may occur between surfaces sliding at low speeds because of the negative slope of the dependence of the coefficient or friction upon velocity. With a coefficient of kinetic friction smaller than the coefficient of static friction, and a latent elasticity in the system of the sliding members, a series of oscillations usually in the nature of "stick-slips" takes place. Such stick-slips cause instability and extensive metallic wear between sliding bodies.

Thus far there have been no published data on the effects of vibration on the static coefficient of friction. This work was undertaken, therefore, to explore the effect of vibration frequency and amplitude on the coefficient of static friction between metallic surfaces.

The effect of sonic vibrations on the coefficient of static friction was measured for highly polished, ground, and sand-pitted steel surfaces. The coefficient of static friction can virtually be made zero between 6 and 42 kc.

"Reduction of Static Friction by Sonic Vibrations," Hans D. Fridman Massachusetts Institute of Technology and Pascal Levesque, Raytheon Mfg Co. Journal of Applied Physics, Oct 1959, 335 E 45 St, New York 17.

*

Hardness Plus Modulus of Elasticity

Based on test performed on the same metallic materials with both cylinder and ball testing apparatus of various sizes, a previously suggested method of simultaneously determining modulus of elasticity and hardness was confirmed. A material constant was developed that is said to be characteristic of the plastic phenomenon in the hardness-testing process. As a result, hardness definitions dependent on load are replaced by a definition independent of test conditions. Hardness is then stated to be a characteristic value determined not only by plastic behavior of the material under test but also the elastic properties of the specimen and test ball.

"On Hardness," Heribert Moser. Zeitschrift fur Metallkunde, No. 234, West Germany. Order translation from SLA translation Center, John Crerar Library, 86 E. Randolph St, Chicago 1.

*

Correlating Bendability with Tensile Properties

Simple equation is presented that correlates minimum bend radius with percentage reduction of area of material. Theoretical derivation as well as experimental data are given, with very good agreement. Consequently, it is proposed that it is possible to predict minimum bend radius for a specific material, given the percentage reduction of area, as determined by standard tensile strength test. Relationship is said to apply to both metals and nonmetals.

"Correlation of Bendability of Materials with Their Tensile Properties," Datsko and Yang, University of Michigan; ASME paper 59-A-110. ASME, 29 W 39th St, New York 18.

*

Photoelasticity

This article discusses two new approaches to the application of photoelasticity to design problems: drilling holes at the end of cracks and studying the stress concentrations that develop around them; examining stresses that develop when shear pins are bent under load.

"Photoelasticity Can Help the Designer," J. J. Dixon, National Engineering Laboratory; Engineering Materials and Design, Dec '59, Drury House, Russell St, London W C 2, England.

*

Consolidation of Distributed Masses

By considering the mass of a body as if it were concentrated at two or more points in space, the solution of static and dynamic balancing problems may be appreciably shortened. Dealing first with centers of gravity and moments and products of inertia, the principle of substitute masses is extended to problems of deflections and vibrations.

"The Consolidation of Distributed Masses," W. H. Sheppard, Mechanical World and Engineering Record, 31 King St W, Manchester 3, England.

*

Bourdon Tubes Tested

To fill the gap in knowledge of Bourdon tube deflection data, the method and results of tests on 70 different flat, oval Bourdon tubes are given. The results are compared against published design data. The results are evaluated to determine the function of the deflection with respect to geometric parameters.

"Tests on Deflection of Flat, Oval Bourdon Tubes," G. Kardos, Aviation Electric Ltd, Montreal, Quebec, Canada; Journal of Basic Engineering, Dec '59, 29 W 39th St, New York 18.

*

Factors in Gear Design

A table of types of gear loads likely to be encountered in 20-odd types of industrial equipment is provided, together with a check list of 12 types of data that should be available before design of gearing begins.

"Presentation of Gear Design Data," R. Gardiner, David Brown Industries Ltd; Engineering Materials and Design, Oct '59, Drury House, Russell St, London W C 2, England.

*

Estimating Vibration and Shock

The methods presented are not to be used as a substitute for measuring vibration and shock, but rather when measurement is not possible. Steady-state excitation, random excitation, shock excitation, limitations imposed by equipment fragility are all discussed.

"Methods of Estimation in Vibration and Shock Problems." C. T. Molloy, Space Technology Laboratories Inc; SAE paper 100W; SAE, 485 Lexington Ave, New York 17.

*

Systematic Evaluation of Fatigue

Various fatigue phenomena are described in quantitative terms and relationships among them are analyzed,

in this attempt to achieve a systematic approach to this problem. Criteria and procedures presented are intended only as a reference framework within which fatigue tests and monitoring in service can be conducted and evaluated. Discusses a device for monitoring fatigue accumulation of in-service structure.

"Quantitative and Systematic Attack on Fatigue," Emory T. Haire, Martin Co; ASTM paper 70. ASTM, 1916 Race St, Philadelphia 3.

*

Safety Factor in Design

Traditionally, a safety factor has qualitative meaning only, but it can be quantitatively interpreted through possible variations in the components of a design, as well as the probability of safety. A proposed statistical method for determining safety factors that is said to give a more rational and more economic design than conventional methods is described and demonstrated.

"Design by Quantitative Factor of Safety," Hsuan-Loh Su, Imperial College, London; ASME paper 59-2-48, 29 W 39th St, New York 18.

*

Deflection of Asymmetric Beams

First the effects of force on symmetric beams are discussed. Then, for the purposes of this paper, a symmetric beam under the action of an oblique force is regarded as asymmetric. A method of determining axes, particularly the principle axes which give deflection in line with applied force is then described.

"The Deflection of Asymmetric Beams," W. H. Sheppard. Mechanical World and Engineering Review, 31 King St W 3, Manchester, England.

*

Corrugated Diaphragms

Solutions of the exact, linear, elastic-shell equations for all stresses and displacements are presented for a typical corrugated-diaphragm shape for three thicknesses varying over a 9:1 range. Results were obtained by numerical integration using an electronic digital computer. The effect of variation in the ratio of thickness to diameter is discussed with respect to both stresses and resultants, and peak values needed for design purposes are presented. Circumferential and meridional stresses are found to be equally important throughout the thickness range analyzed. Bending and membrane stresses are likewise equally important throughout the range. Peak values in some cases occur near the outer rim.

"Bending and Stretching of Corrugated Diaphragms," Robert F. Dressler, National Bureau of Standards, Journal of Basic Engineering, Dec '59, 29 W 39th St, New York 18.

*

Impact Fatigue Strength

Experiments which yielded differences between impact fatigue strength and ordinary fatigue strength values are described, and effects of varying diameters of test bars given. Data on scale factor for low vs high-temperature tempered specimens is also included.

"Study of Impact Fatigue Strength," N N Davidenkov and E I Belyayeva, Transactions of Metalovedenize i Abrabotka, Metallov, April 1959, USSR. Translation available from Henry Brutcher, PO Box 157, Altadena, Calif.

*

Mechanism of Thermal Fatigue

Mechanics of thermal fatigue (sometimes called "fire cracking") are described and equipment and procedure used for experimental verification discussed. Importance of proper design and the selection of alloys combining high hot strength with low thermal expansion coefficients is pointed out.

"The Mechanism of Thermal Fatigue," H S Avery, American Brake Shoe Co. Metal Progress, Aug 1959, 7301 Euclid Ave., Cleveland 3.

*

Cutting Stock Springs to Length

A quick method for determining the appropriate lengths to which long-length stock compression springs should be cut for specific applications is described. Author tells how to construct proportion charts to determine spring length under certain loads and deflection forces; loads imposed by given amounts of deflection; loads developed by specific length and stroke; length of spring required for given load and stroke. Several examples are included.

"Selecting Springs from Stock Lengths," Raymond D. Bohannon, Kingsbury Machine Tool Corp; Tool Engineer, Jan '60, 10700 Puritan Ave, Detroit 38.

*

Developing Cam Charts

Well-balanced cam systems are essential to the proper performance of four-slides, screw machines and most automatic machinery. Optimum cam systems can be designed using a graphical method described by the author.

"Developing Cam System Charts for Optimum Performance" by Werner Vogt, Torrington Mfg. Co. Tool Engineer, March 1960, 10700 Puritan Ave, Detroit, Michigan.

*

Parameters for Compression-spring Design

Presents a system of parameters to enable the engineer to portray graphically the complex variables involved in the design of springs for specific sets of operating conditions. Derivations are based on number of coils as well as OD, which is represented as accurately defining the entire space required for the spring. Charts are included for springs with two dead coils and a torsion modulus of 11,500,000 psi.

"Dimensionless Parameters for Helical Compression Springs," R. J. Erisman, International Harvester Co; ASME paper 59-A-30. ASME, 29 W 39th St, New York 18.

*

Damping for Vibration Control

The use of system damping of vibration is discussed, particularly in reference to hysteretic damping within structural materials and structural damping associated with interface slip (Coulomb friction) and shear strain in an adverse layer at an interface. These mechanisms are analyzed and the possibilities of using them in controlling vibration discussed.

"Material and Structural Damping for Vibration Control," B. J. Lazan, University of Minnesota. Society of Automotive Engineers paper 100U, 485 Lexington Ave, New York 17.

From: ASME Paper

DESIGN CURVES for JOURNAL BEARINGS

Design curves for full journal bearings of finite length illustrate the variation of minimum film height with load variable, and the variation of the coefficient friction with the Sommerfeld number.

DONALD F. HAYS
Research Laboratories
General Motors Corporation

In the design of journal bearings, it is important to be able to tie together the relationships existing between the operational geometry of the bearing and such parameters as load, speed, viscosity, length-to-diameter ratio, and clearance ratio. Until recently these relationships were difficult to ascertain because of the difficulties in obtaining a solution to Reynolds' equation for the finite bearing. Either the assumption of an infinitely long bearing was accepted, or a bearing which was extremely narrow was postulated and the results obtained were used with considerable reservation when outside of the limited range of L/D ratios. There is now a technique whereby a finite bearing can be analyzed for all its characteristics. The design curves presented here apply to journal bearings of finite length with a continuous oil film. The lubricant is assumed to be incompressible and the Reynolds Number small.

Symbols

C = radial clearance, in.
D = bearing diameter, in.
L = bearing lenth, in.
LV = load variable $= [Y/(\mu RN)]\,(C/R)^2$
N = speed, RPM
P = average pressure $= W/(LD)$
R = bearing radius, in.
S = Sommerfeld Number $= (\mu N/P)\,(R/C)^2$
W = load, lb
Y = load per unit length $= W/L$
f = coefficient of friction
h_m = minimum oil film height, in.
ϵ = eccentricity ratio
μ = viscosity, Reyns

Examples

The following examples help illustrate the ways in which these curves may be used. The examples are given only to familiarize the user with the curves and not intended to reflect actual bearing problems.

1—Known: Physical geometry of bearing, viscosity of lubricant, minimum film height at which the bearing should operate. **Required:** Total bearing load that could be sustained, and power loss due to viscous shear:

$R = 1$ in. $\quad C = 0.001$ in.
$L/D = 0.3 \quad \mu = 2 \times 10^{-6}$ reyns
$N = 1000$ rpm $\quad h_m = 0.0001$ in.

Therefore

$$h_m/C = 0.0001/0.001 = 0.1 \qquad (1)$$

From the intersection of the curve in Fig. 1B for $L/D = 0.3$ and the line for $h_m/C = 0.1$, read down and obtain a value of 0.42 for the load variable.

Thus

$$[Y/(\mu RN)]\,(C/R)^2 = \frac{Y(0.001)^2}{[(2\times10^{-6})(1)(1000)]} = 0.42 \qquad (2)$$

whence

$$Y = 840 \text{ lb/in.} \qquad (3)$$

$$W = YL = Y(L/D)(2R) = (840)(0.3)(2) = 504 \text{ lb} \qquad (4)$$

In order to find the power loss, the Sommerfeld number must be known. This can be found by computing the ratio shown in the "Symbols" or it may be found from the following relationship,

$$(\text{Load variable}) \times (\text{Sommerfeld number}) = 2.0 \qquad (5)$$

Thus

$$S = 2/0.42 = 4.77 \qquad (6)$$

From the intersection of the curve in Fig. 2A for $L/D = 0.3$ with the line for $S = 4.77$, the coefficient-of-friction variable is found to be 4.0. Thus the coefficient of friction can be determined as shown

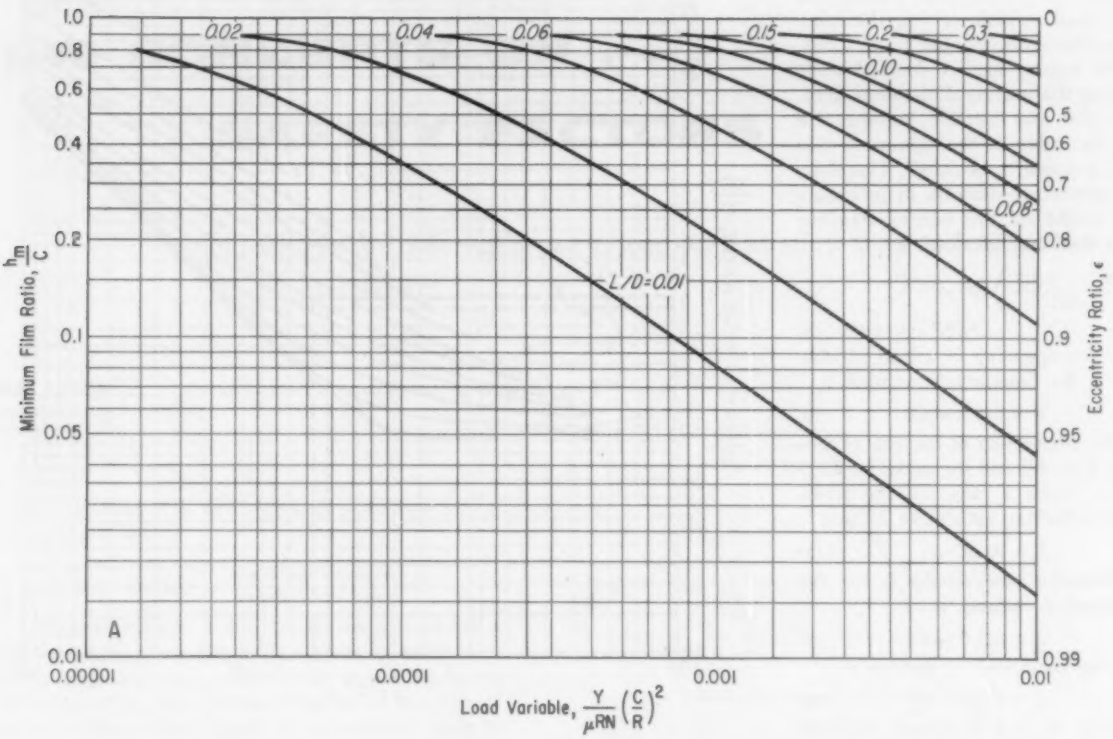
$$f = 4(C/R) = 4(0.001) = 0.004 \qquad (7)$$

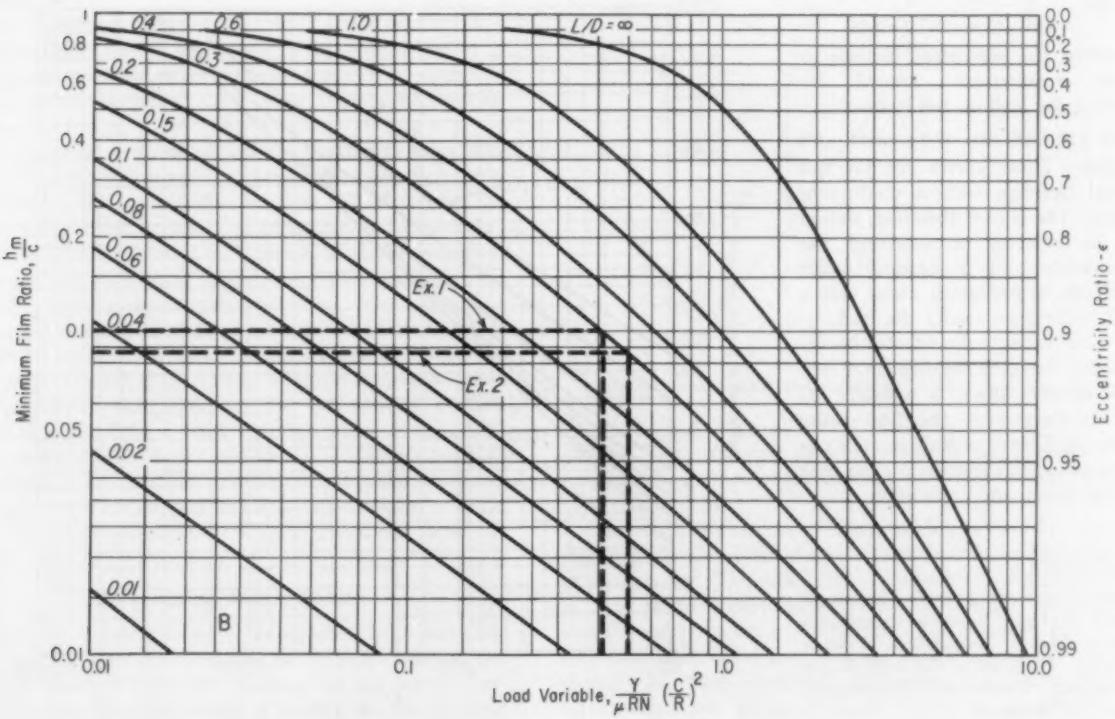
and the power loss is computed to be

$$HP = (1.587\times10^{-6})\,RNfW \qquad (8)$$
$$= (1.587\times10^{-6})(1)(1000)(0.004)(504)$$
$$HP = 0.032$$

2—A bearing of specified dimensions is known to be operating at a certain value of the load variable. If the bearing load should be altered, what would be the effect upon the minimum film ratio and upon the power consumption? Consider a bearing with $L/D = 0.3$ and operat-

1. . Minimum film height variation with load variable.





ing with a load-variable value of 0.5. From the intersection of the curve for $L/D = 0.3$ and the vertical line for a load variable of 0.5, the minimum film ratio is found to be 0.087. If the bearing load is doubled while holding the bearing dimensions fixed, then the load variable becomes 1.0 and the value of the minimum film ratio is found to be 0.047. Therefore, the percentage decrease in minimum film height for this bearing resulting from doubling the load is

$$\left(\frac{0.087 - 0.047}{0.087}\right) 100 = 45.98\% \text{ decrease} \quad (9)$$

When operating at a load variable of 0.5, the Sommerfeld number is

$$S = 2/0.5 = 4.0 \quad (10)$$

The intersection of the line of constant $S = 4.0$ and the curve for $L/D = 0.3$ yields a value for the coefficient of friction variable of 3.6 and

$$f_1 = 3.6\,(C/R) \quad (11)$$

When the load variable is 1.0, the Sommerfeld number is

$$S = 2/1.0 = 2.0 \quad (12)$$

and the coefficient of friction is

$$f_2 = 2.65\,(C/R) \quad (13)$$

Since μ, R, and N remain constant,

$$HP_1/HP_2 = (f_1W_1)/(f_2W_2) = 3.6W_1/[2.65(2W_1)] = 0.68 \quad (14)$$

Therefore, the percentage increase in power requirement caused by doubling the load on the bearing is

$$(0.68 - 1.0)/0.68]\,100 = 47.0 \text{ per cent} \quad (15)$$

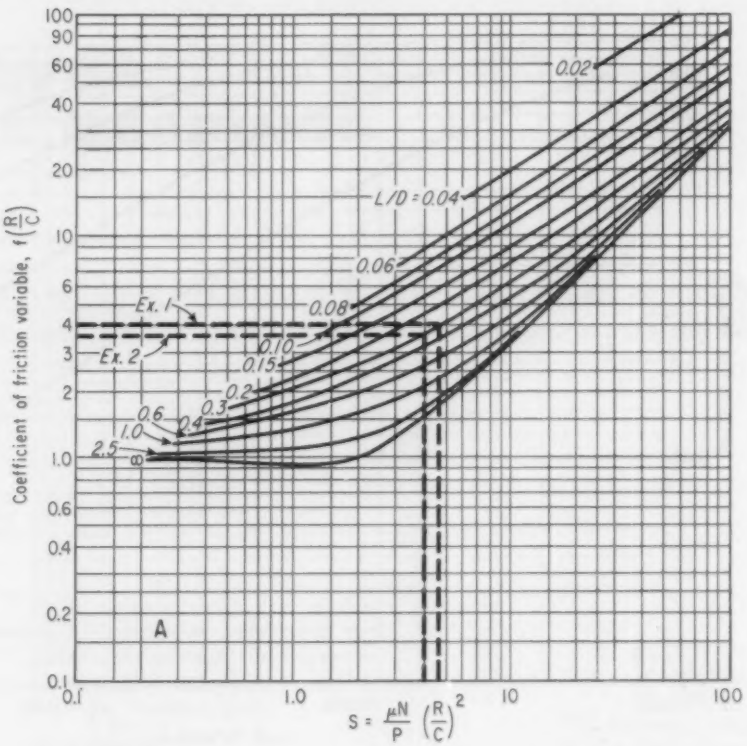
Caution: These curves are for full journal bearings with a continuous oil film. The curves, therefore, should not be expected to represent the characteristics of a bearing under conditions of cavitation where only a small bearing arc carries the load.

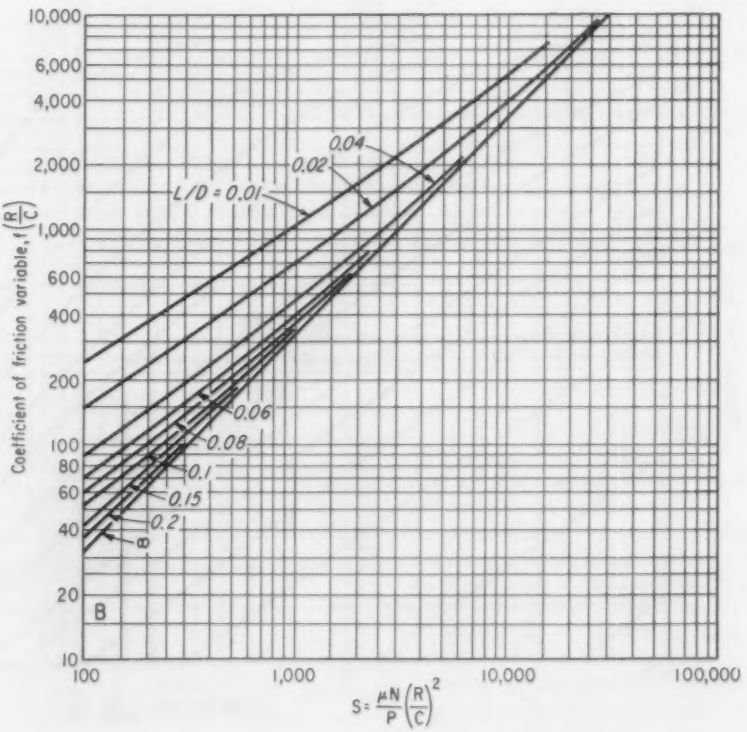
A heat balance should also be determined for each bearing that will show whether there is sufficient oil flow to carry away the heat being generated. Curves of leakage rates can be found in the literature dealing with bearing design and application.

REFERENCE:

Design Curves for Journal Bearings by Donald F. Hays, Research Laboratories, General Motors Corporation, Warren, Michigan. Presented at the 1959 Design Engineering Conference, Philadelphia, Paper No. 59-MD-11.

2. Variation of friction with Sommerfeld Number





From: SAE Paper

NEW CONCEPTS ON . . . SAFETY FACTORS

4 methods for different types of loading that allow truer safety factors to be calculated.

CHARLES LIPSON
Professor, Mechanical Engineering
University of Michigan

The true meaning of a factor of safety can best be expressed in the form:

$$\text{Factor of safety} = \frac{\text{significant strength}}{\text{significant stress}}$$

The significant strength is the actual strength which a member possesses under the actual operating conditions. It is often referred to as the allowable stress and it is determined by correcting the ultimate strength for the type of loading, size effect, surface finish, life expectancy, mode of loading, etc.

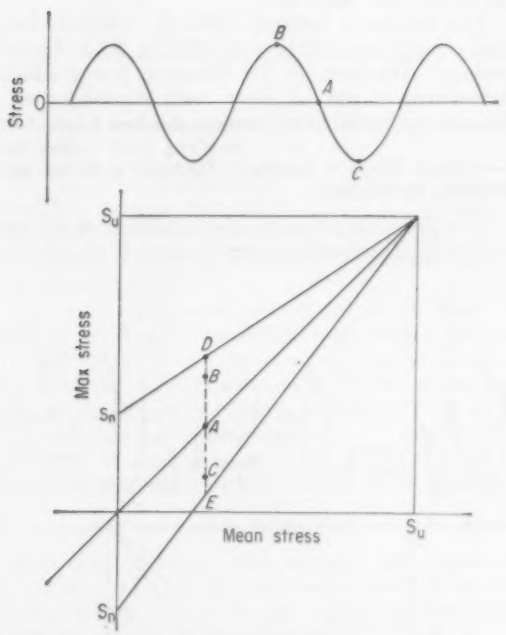
The significant stress is the actual stress existing in a member under the actual operating conditions and it is determined by multiplying nominal stresses, corresponding to the actual operating loads, by a stress concentration factor.

The decision as to whether a given safety factor is adequate must be determined for each design, since each member is essentially an individual problem. Consequently, the safety factor must be based on judgment and experience, with the consideration of such factors as the consequence of failure and economical production. When the unknown factors affecting the significant stress and significant strength can be reduced to a minimum, a safety factor as low as 1.3 represents adequate insurance against failure. At the other extreme, if the factors affecting significant stress and significant strength are not too well defined, a safety factor of 2 should be applied.

Since these safety factors are arrived at through the consideration of the principal variables affecting the stress and strength of a member, it is not necessary to assign to them the high values associated with the conventional factors of safety.

Determining Safety Factors

Although a safety factor is determined from the consideration of both the stress and the strength analysis, the manner in which these two analyses are compared, however, depends upon the pattern of loading and the resulting stresses. Four different patterns of stress are considered here and the method of determining the factor of safety for each is indicated.



1. Conventional method of determining factor of safety.

Conventionally, factor of safety is determined by constructing the Goodman diagram to represent the strength of the member. The various stress components ($\sigma_{max.}$, $\sigma_{mean.}$ $\sigma_{min.}$, $\sigma_{var.}$) are superimposed upon the strength diagram and the safety factor is determined. For example, Fig. 1 illustrates the Goodman diagram which represents the strength of some members, determined for the actual service conditions involved. It also illustrates the stress to

TABLE—Factors of Safety for Compressors Head Bolts

Bolt size, in.	A_s (in.^{2})	$\sigma_{min.}$ (psi)	σ_{mean} (psi)	$\sigma_{max.}$ (psi)	$\sigma_{var.}$ (psi)	S_y (psi)	Factors of Safety	
							Based on excessive tightening torque	Based on excessive gas pressure
1/2	0.1374	37,500	39,600	41,700	4,200	46,000	1.22	3.83
9/16	0.1816	27,800	29,650	31,510	3,710	46,000	1.65	5.90
5/8	0.2256	22,100	23,680	25,260	3,160	46,000	2.08	7.70

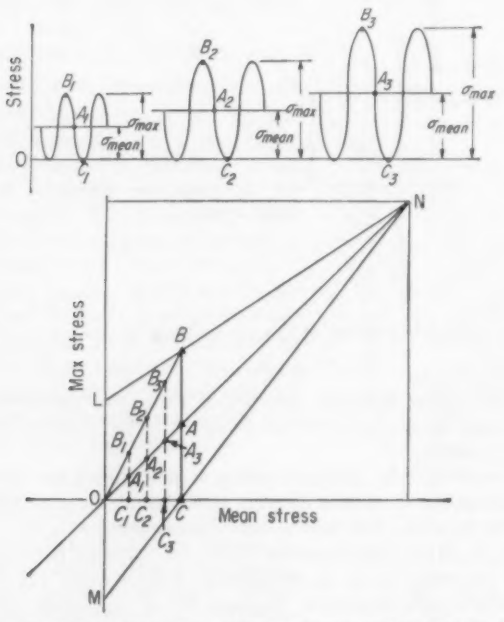
which the part is subjected. The mean stress plotted on the Goodman diagram, defines point A. The variable component of stress defines points *B* and *C*. Thus the stress fluctuates between *B* and *C*. At this particular mean stress the fluctuating stress could reach a magnitude of *AD* before failure would occur. Thus, the factor of safety for this case equals the allowable stress range *DE* divided by the actual stress range *BC*.

This procedure, however, although valid for this particular case, may not be applicable to other fluctuating loadings. Therefore, in the following four methods of determining factors of safety, each depends upon the physical significance of the stresses involved.

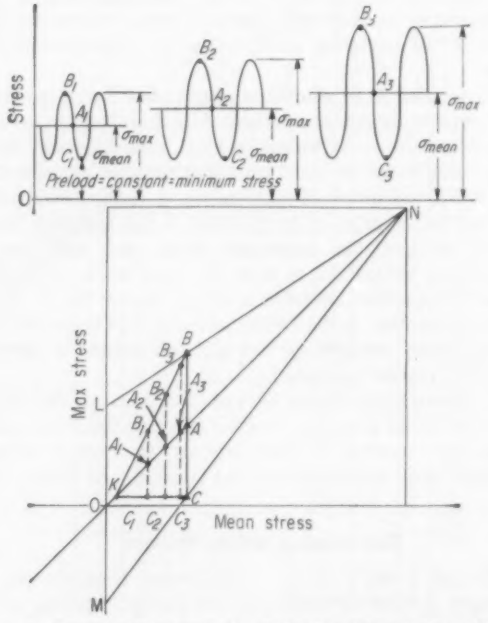
I—Preload stress is constant, fluctuating stress varies, additive to preload

It is easiest to approach this condition if the special condition of no preload (zero minimum stress) is considered initially. Fig. 2 illustrates the stress pattern for this type of loading where the external stress fluctuates from zero to a maximum and then back to zero.

In Fig. 2, the mean stress is plotted on the Goodman diagram and it defines point A_1. The maximum stress is point B_1 and the minimum stress C_1 since the preload is zero giving a zero minimum stress. When the values of mean and maximum stress are plotted for different external load fluctuations, points A_2, B_2, C_2 and A_3, B_3, C_3 are determined. The mean stress points A_1, A_2, A_3 all lie along the steady stress line *NO* having a slope of 1, and the maximum stress points B_1, B_2, B_3 all lie on a line *OB* of slope 2 since the maximum stress is twice the mean stress for this case. The maximum stress line *OB* intersects the maximum strength line *LN* at point *B*, thus defining the maximum allowable stress. The factor of safety is thus the maximum allowable stress range *BC* divided by the actual stress range B_1C_1, B_2C_2, or B_3C_3.

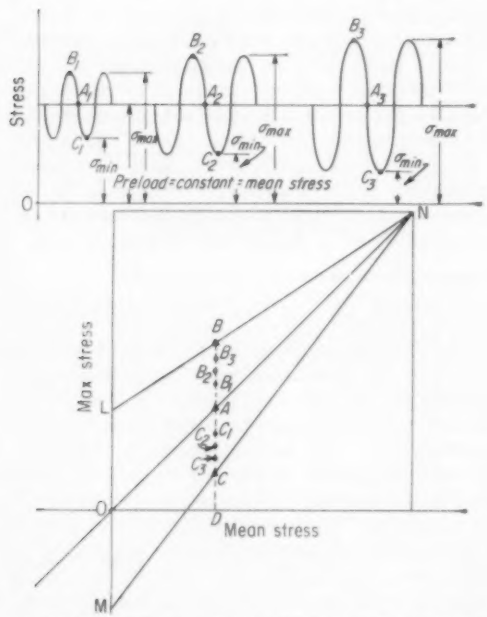


2. Preload stress zero, fluctuating stress varies, additive to preload.



3. Preload stress constant, fluctuating stress varies, additive to preload.

This type of loading can now be extended to the general case where the preload is not zero. The resulting stress pattern is shown in Fig. 3 where the minimum stress C is constant corresponding to the preload. Plotting the stress values on the Goodman diagram, the minimum stress points will lie along a horizontal line $C_1C_2C_3$ parallel to the abscissa. The mean stress values A_1, A_2, A_3, will all lie on the steady stress line NO and the maximum stress points B_1, B_2, B_3 will lie on the line KB of slope 2, having its origin K at the intersection of the minimum and steady stress lines, KC and NO respectively. Thus the factor of safety can be expressed as the allowable stress range BC divided by the actual stress range B_1C_1, B_2C_2, B_3C_3.

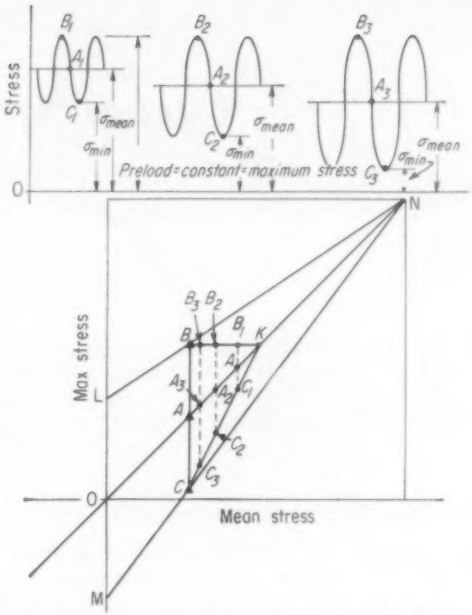


4. Preload stress constant, fluctuating stress varies, completely reversed about preload axis.

II—Preload stress is constant, fluctuating stress varies, completely reversed about preload axis

If a member has a constant preload and a fluctuating external load which both adds and subtracts from the preload, a stress pattern is set up as shown in Fig. 4. If the magnitude of the external load is changed, the σ_{max} and σ_{min} will also change but the σ_{mean} will remain constant.

If the stresses are plotted on the Goodman diagram (Fig. 4), the mean stress will be represented by A on the steady stress line. The points B_1 and C_2 then correspond to the σ_{max} and σ_{min} respectively. Thus, the values of minimum and maximum stress lie on a vertical line BD whose location is determined by the value of the constant mean stress. The maximum allowable stress range will be determined from the intersection of this vertical line with the lines LN and MN. The factor of safety is then the allowable stress range BC divided by the actual stress range B_1C_1, B_2C_2, or B_3C_3.



5. Preload stress constant, fluctuating stress varies, subtractive from preload.

III—Preload stress is constant, fluctuating stress varies, subtractive from preload

If a member is subjected to a constant preload and a fluctuating external load which opposes the preload, the pattern of stresses will be as illustrated in Fig. 5. The maximum stress will remain constant while the σ_{mean} and σ_{min} both will change.

When the stresses are plotted on the Goodman diagram, the maximum stress B will always lie on a horizontal line BK parallel to the abscissa since σ_{max} is being held constant. The mean stress A_1, A_2, A_3 will lie on the steady stress line NO while the minimum stress C_1, C_2, C_3 will determine the line CK of slope (-2). Factor of safety is thus the allowable stress range BC divided by the actual stress range B_1C_1, B_2C_2, or B_3C_3.

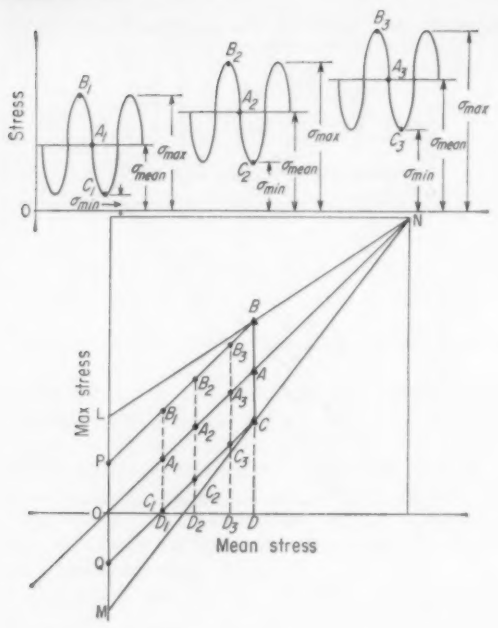
IV—Preload stress varies, fluctuating stress is constant

If loading conditions were imposed that allowed the mean stress to be changed but which caused the external fluctuating load range to remain constant, a stress pattern would be set up as shown in Fig. 6.

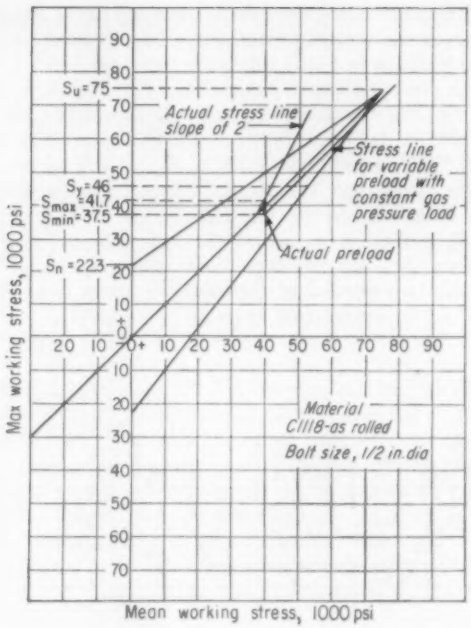
When the values of stress are plotted on the Goodman diagram, the lines $B_1B_2B_3$ and $C_1C_2C_3$ are parallel to the steady stress line NO because the stress range is being held constant. The intersection of the constant stress range lines PB and QC with the maximum and minimum strength lines LN and MN at B and C respectively determines the maximum allowable mean stress AD. The safety factor is thus the allowable mean stress AD divided by the actual mean stress A_1D_1, A_2D_2, A_3D_3.

APPLICATION TO COMPRESSOR BOLT DESIGN

These concepts can be effectively applied to a variety of engineering problems, as illustrated by a problem that



6. PRELOAD STRESS varies, fluctuating stress constant.



7. GOODMAN DIAGRAM for compressor head bolts.

involved designing bolts to seal the head of a reciprocating compressor having a bore of 10.5 in. The pressure in the cylinder varied from 0 to 200 psi.

Initial analysis indicated that six bolts were necessary for adequate sealing. The problem then resolved itself to the determination of bolt size.

The stresses were determined from the conventional relationships where C = 2:

$$F_i = C F_e \left(\frac{K_c}{K_b + K_c} \right)$$

and

$$F_t = F_i + \left(\frac{K_b}{K_b + K_c} \right) \times F_e$$

$$\sigma = \frac{F_t}{A_s}$$

where

F_i = tightening load
F_e = external load due to gas pressure
F_t = total load acting on the bolt
σ = stresses resulting from the above loads
A_s = stress area of the bolt
K_b = elastic constant of the bolt
K_c = elastic constant of the mated members

Table I gives the stresses in the bolt for three bolt sizes: ½-in., ⅞-in. and ⅝-in. dia. The stresses for the ½-in.-dia bolt, in turn, are plotted on the Goodman diagram, as shown in Fig. 7, from which factors of safety can be determined. In determining these factors two cases must be considered:

1—Where the tightening load can be taken as constant and the only consideration is that the design must be guarded against increases in gas pressure, with a resultant failure of the bolt.

2—Where the gas pressure can be accepted as reasonably constant and the design must be guarded against overtorquing the bolt, with the resultant bolt failure.

Obviously the design must be strong enough to avoid both eventualities. The first belongs to the category of Case I, since the preload (tightening torque) is constant, and the fluctuating stress (gas pressure) varies, being additive to the preload. The second is illustrated by Case IV, since the preload (tightening torque) varies and the fluctuating stress (gas pressure) is constant. Accordingly two factors of safety are determined, as shown in Fig. 7 and Table I. Where the gas pressure is constant and tightening torque varies the limiting stress in Fig. 7 is taken as the yield point of the material (S_y in Table) to conform to general engineering practice.

Of the two factors of safety determined above, the one governed by possible excessive tightening is smaller, Table I, than the one from possible excessive gas pressure. Therefore, the design of this fastening is governed by avoidance of overtorquing.

This factor of safety for the ½-in.-dia bolt, as determined from Fig. 7 is 1.22 and therefore not sufficient for a failure-free operation. The ⅞-in.-dia bolt gives factor of safety of 1.65, which appears adequate. For critical applications it might be necessary to go to ¾ in. dia (factor of safety of 2.08), though this may lead to possible overdesign if the requirements are less stringent.

REFERENCE:
New Concepts in "Factor of Safety" Applicable in Design of Engines by Charles Lipson, Professor, Mechanical Engineering, University of Michigan, Ann Arbor, Michigan. Presented at the SAE National Diesel Engine Meeting, Chicago, Oct 59. Paper No. 120T.

From: ASME paper

WHICH BEARING and why?

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Research Engineer
Research Laboratories
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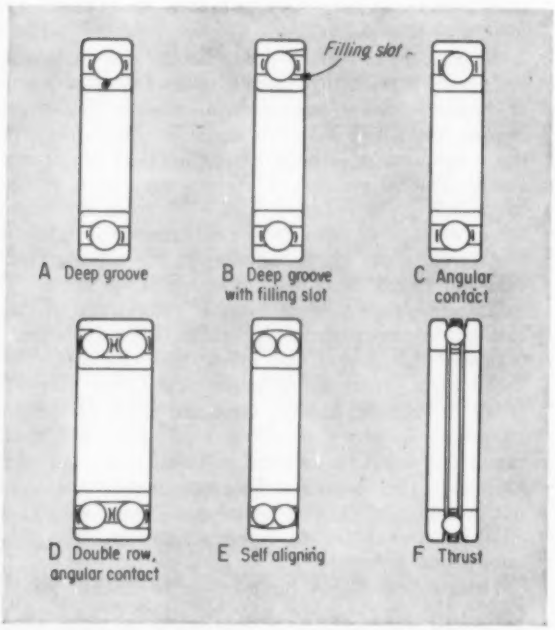
The machine designer is faced by a formidable and seemingly endless array of bearing types from which to make a selection that he hopes will do the job in a finished machine. Most of the time, the selection is made the easy way—by choosing from the particular catalogs which happen to be handy in his files. Following this course, he may or may not make the best choice; in any rational design all factors should be weighed before the final selection is made. Rather than competing, each bearing has its own particular advantages and disadvantages and the selection will often be a compromise.

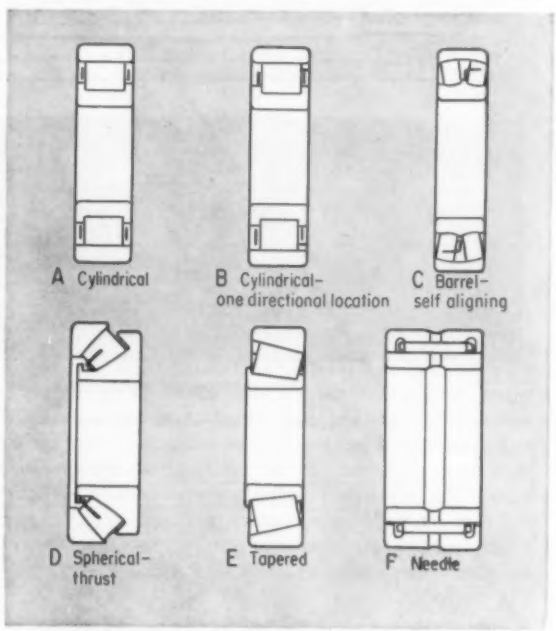
In order to help the designer in this dilemma, a survey of the pertinent selection factors is given in Table 1. This table should help to determine "which" bearing. An examination of the construction and some of the operation features of the bearings should determine the "why".

ROLLING-CONTACT BEARINGS

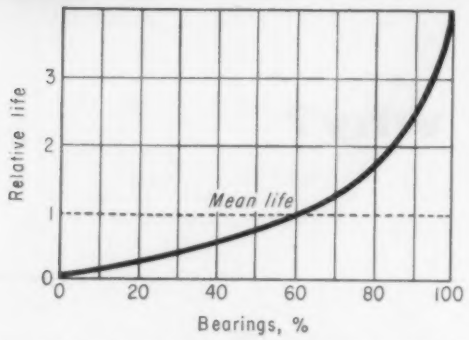
The term "rolling contact" or "rolling element" is more descriptive than the popular term "antifriction" bearing. True, the starting friction of rolling-contact bearings may be considerably less than the usual hydrodynamic-



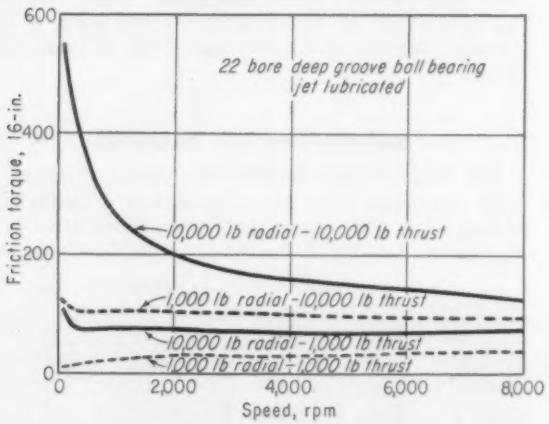
1. BALL BEARINGS with standard deep groove (A) are most versatile. Extra balls (B) increase radial load capacity at expense of high-speed performance and thrust-load capacity. Good thrust- and radial-load performance is given by angular contact design (C). Most high-speed and precision spindles use axially preloaded pairs of these bearings, but the double-row type (D) is simpler to use—preload is built-in at factory. Self-aligning design (E) tolerates much misalignment of housing and shaft but load capacity is reduced due to the high contact stresses that result from the large difference in curvature between the balls and the outer race. The thrust ball bearing, (F), is adaptable to large thrust loads that have almost no radial component. Very large sizes of this bearing are used in gun turrets and large earth moving machinery.



2. ROLLER BEARINGS can support greater loads than ball bearings but are not as versatile as the ball bearing. Cylindrical bearing (A) takes only radial load and permits some axial motion of shaft. Shoulders (B) let bearing withstand light axial loading. Sperical bearing (C) is self-aligning without loss of load capacity. It is best for low-speed use. Barrel-shaped roller in thrust bearing (D) takes large loads with reasonable mis-alignment but available sizes are large. Tapered type (E), usually mounted in pairs, is available in a full range of sizes. Needle bearing (F) takes less space than a standard roller bearing, and where necessary, the needles can be run directly between a hardened shaft and housing. Skewing may be a problem at high speeds, when a separator is used with some loss of load capacity.



3. VARIATION OF FATIGUE LIFE OF BALL BEARINGS.



4. EXPERIMENTAL FRICTION-TORQUE CURVES for a ball bearing. These curves differ greatly from those given by the usual formulas. It was observed that changing the bearing geometry, method of lubrication, or separator design can affect the friction markedly. The abrupt drop in torque as the speed increases is probably caused by the building up of a hydrodynamic lubricant film between the rolling elements and the races.

type bearing; but running friction of these two types is often comparable—the relative values being dependent upon the design and application. And, of course, externally pressurized bearings can be made such that the friction approaches zero as the relative velocity approaches zero. Rolling-contact bearings certainly reduce friction, but they merit the term "antifriction" no more than many other types. Two main types of rolling-contact bearing, ball and roller, are discussed in Figs. 1 and 2.

Bearing Life

The life of rolling-contact bearings is usually limited by fatigue. The actual load-carrying area of the rolling elements is small so that the unit pressures are high. For example, the contact area between a ¾-in.-dia ball and a flat plate may be calculated to be only about 0.00015 sq in. when the force pushing them together is 22 lb. Under these conditions, the maximum calculated compressive stress is 200,000 psi.

What death and taxes are to man, fatigue is to rolling-contact bearings. If a large group of bearings are run until failure and the distribution function of their lives plotted, the curve looks somewhat like Fig. 3. When a bearing is installed in a machine, no one knows where on the curve it lies—the possibility of an early failure is most disturbing. Bearing manufacturers are greatly concerned about early failures and have done considerable work to reduce them.

Rolling-contact-bearing load ratings are determined statistically with actual fatigue tests of a large number of bearings. Some bearing manufacturers give average bearing life, which is known as "B-50" life, while others use a figure called "B-10" life. The B-10 life rating is the life that 90 per cent of the bearings can be expected to exceed at the indicated load. The loads for bearing-life expectancy are listed by the manufacturers. They also give formulas for the calculation of life expectancies at load and speeds other than those which are listed. The manufacturers give much valuable information in their catalogs on proper bearing application and installation. A customer should read and follow the information published there. One manufacturer found that over 95% of all ball-bearing troubles were the result of defective mounting, improper operating conditions, and similar causes that could be detected by visual inspection of the bearing. The manufacturers' recommendations should not be taken lightly; they spend much time, money, and effort in accumulating the experience on which the catalog information is based.

There is one subject, however, on which little information is available—bearing friction. Don't overlook the data in Fig. 4.

Advantages of rolling-contact bearings are that they:

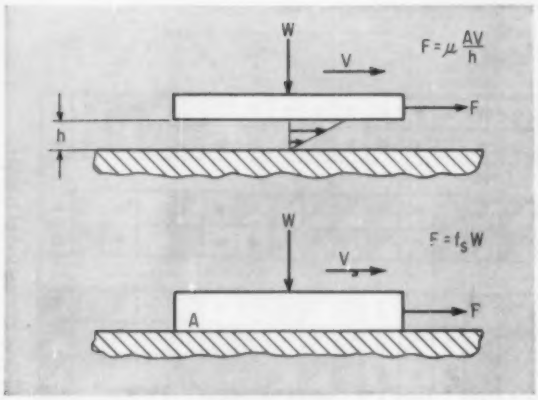
- Maintain accuracy.
- Are relatively insensitive to oil-flow interruption.
- Are insensitive to momentary overloads.
- Have low friction torque under moderate load.
- Can be used without external oil system.

Disadvantages are that they:

- Are large.
- Have low tolerance to dirt and abuse.

SYMBOLS

A = area, sq in.
A_E = effective area, sq in.
b = width of flow path, in.
c = radial clearance, in.
e = eccentricity, in.
F = friction force, lb
f_s = coefficient of sliding friction
h = film thickness, in.
L = length, in direction of flow, in.
p_o = supply pressure, psi
p = pressure, psi
V = velocity, in. per sec
W = force, lb
ϵ = eccentricity ratio
μ = coefficient of absolute viscosity, lb-sec/sq in.



5. LUBRICATED AND NONLUBRICATED SLIDING.

Have high noise and vibration levels.
Have unpredictable life (of a single bearing).
Have low tolerance to large dynamic loads.
Are expensive.

Relative ratings based upon specific performance requirements are given in Table 1. This table will help the designer in selecting "which" bearing. Obviously, the large number of special type bearings precludes rating none but the more standard types, and it must be remembered that for a special application there may be bearings of specific design that circumvents the disadvantages of the standard designs.

FLUID-FILM BEARINGS

Fluid-film bearings–known variously as plain bearings, journal bearings, sleeve bearings, sliding bearings, etc.–are the most used and least understood of the bearing types. Viscous fluid friction is substituted for the rolling friction of the rolling-contact bearings or the sliding friction of non-lubricated bearings, Fig. 5. With a fully developed fluid film there is no contact between the parts that have relative motion; it follows that there can be no wear or sliding damage to the surfaces. With a Newtonian fluid, the friction force is given by

$$F = \mu (AV/h)$$

With dry friction, the force is a function of only the applied load and the coefficient of sliding friction

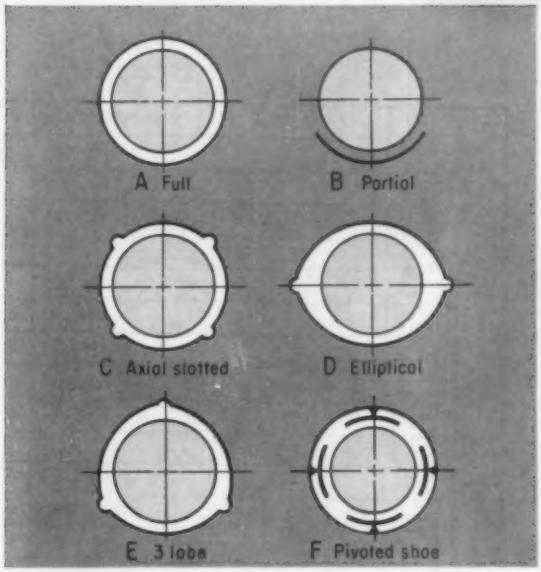
$$F = f_s W$$

Critical examination of these formulas shows that, contrary to popular conception, fluid-film friction can be higher, equal to, or less than dry sliding friction.

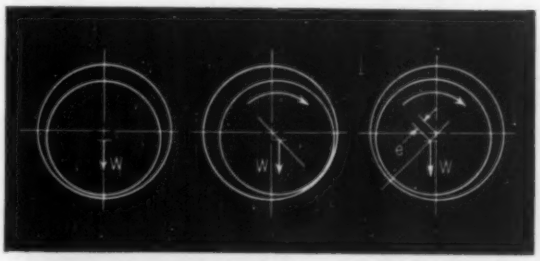
The load-carrying capacity of a hydrodynamic bearing is the integral over the effective bearing area of the fluid pressure acting to support the applied load. This pressure that acts to support the load can be generated within the bearing or can be supplied externally.

Self-pressurized Bearings

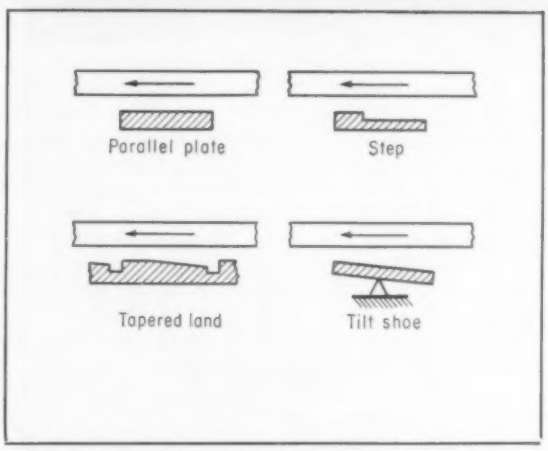
When the bearing generates its own load-carrying pressure, the methods of generation can be divided roughly



6. **FULL JOURNAL BEARING.** (A) often with an oil groove, is by far the most universally used bearing—today as much as in the day of the Roman chariots. Very high loads can be tolerated, and the bearing operates over a wide range of radial loads and speeds. When the load is nearly unidirectional and the speed is not high, the partial journal bearing (B) can be used. Both the full and the partial journal bearing are unstable at high speeds and light loads. Several designs have improved stability. In the order of increasing stability the bearings are axial slotted (C), elliptical (D), three-lobe (E), and pivoted-shoe bearing (F).

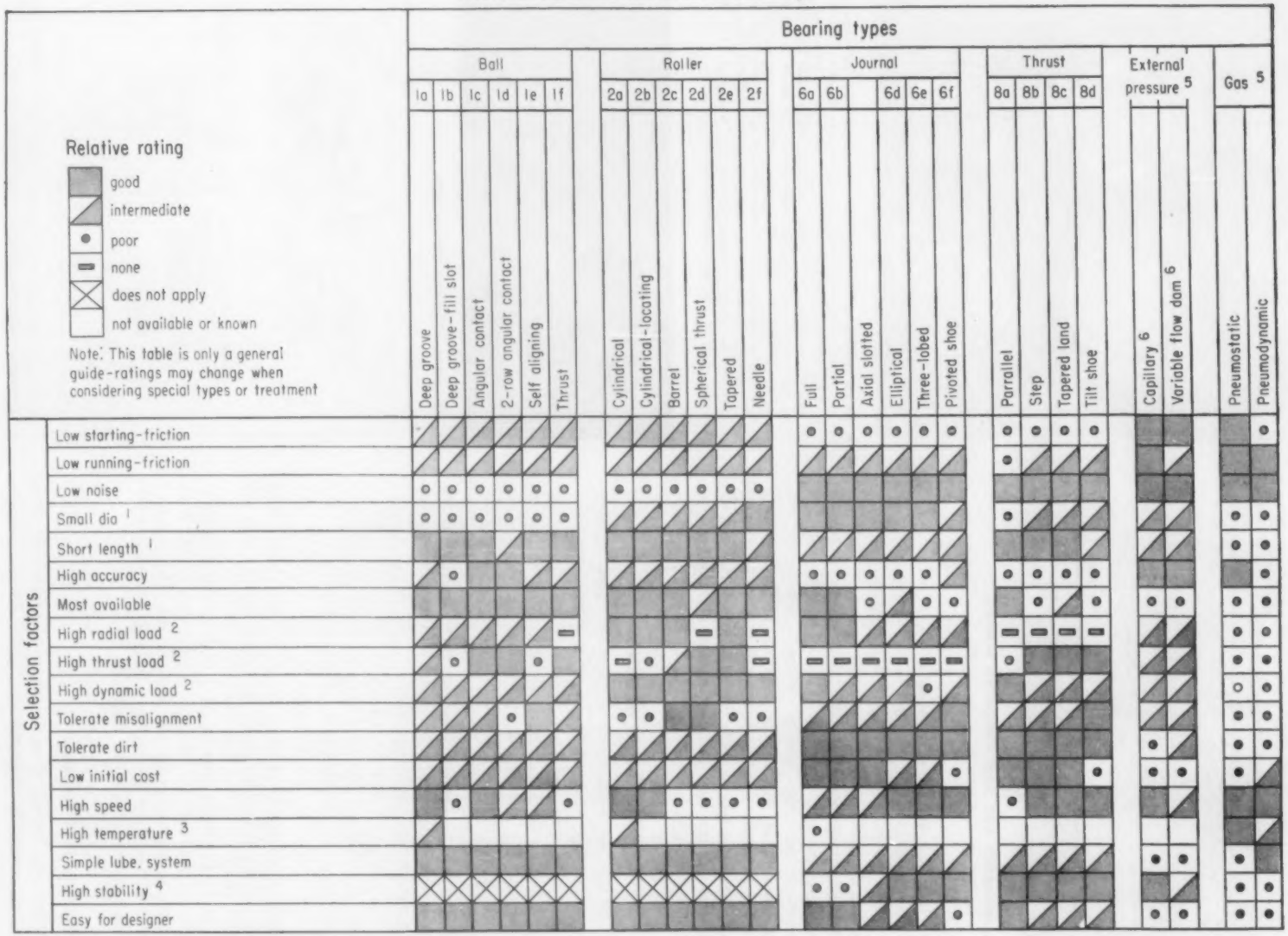


7. JOURNAL-BEARING OPERATION.

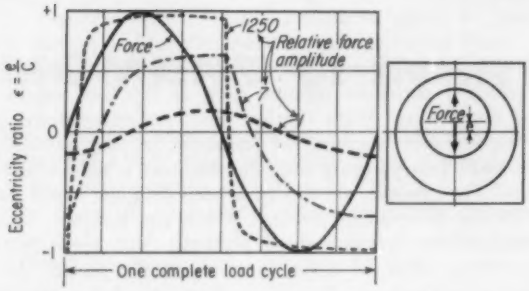


8. TYPICAL THRUST-BEARING CONFIGURATIONS.

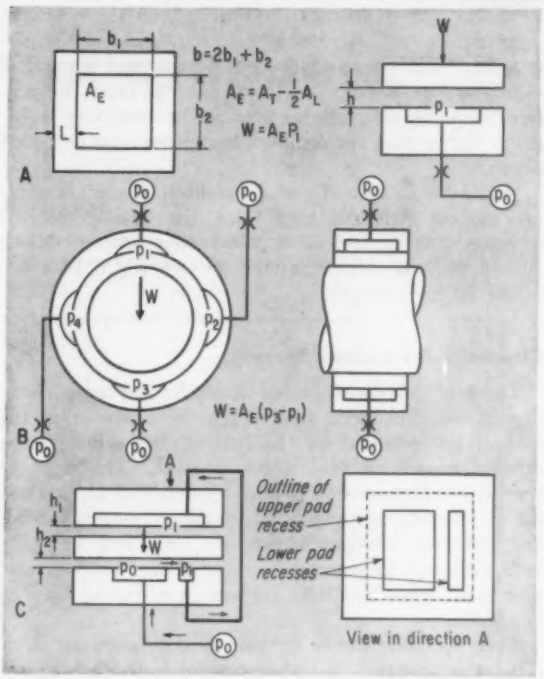
Table 1-Selection factors for Bearings



1 With a given load (radial or thrust). 2 With a given size. 3 Above 450F. 4 Applies to high-speed fluid-film bearings. 5 Journal or thrust type. 6 Restrictor controlled (liquid).



9. ECCENTRICITY RATIO of journal bearing with sinusoidal loading and no rotation.



10. EXTERNALLY PRESSURIZED LOAD-LIFT BEARINGS.

as follows into two general classes: Geometry induced, load induced.

Geometry Induced. The most commonly used hydrodynamic bearing is the type in which fluid-film pressure is induced by the effect of geometry. In the journal bearing, the rotating shaft is slightly smaller than the bearings and the load causes it to move off center. This movement causes a converging section to be formed; which, owing to the viscous drag of the lubricant, induces a high-pressure region that supports the load. Journal bearings are generally not "off-the-shelf" items, so there is a wide variety of shapes and designs (probably as many as there are people who have designed bearings). A few of the many possible journal-bearing configurations are shown in Fig. 6.

The operation of a simple cylindrical journal bearing is shown in Fig. 7. When the bearing is at rest, the applied load causes the journal to rest on the bearing surface. When rotation of the journal starts, it first rolls on and then slides against the bearing with only boundary lubrication. Some bearings operate in this manner in service but they require special additives that form tenacious surface films and prevent excessive wear and damage. If possible, such operation is to be avoided. As the journal is driven faster, enough oil may be forced into the converging wedge formed by the clearance of the bearing to lift the journal from the bearing surface. Normal hydrodynamic operation with unidirectional loading now occurs.

Obviously, one of the most critical operating conditions is encountered during start. This is when the bearing wears and scores. Not only must the bearing material be selected to prevent scoring and galling, but attention must also be given to its fatigue resistance, corrosion resistance, and embedability. The selection of a bearing material is often a compromise.

In any complete bearing design, a heat balance must be made to determine whether the temperature rise is excessive. Practically any fluid may be (and probably has been) used for lubrication. The major requirement in a hydrodynamic bearing is that the fluid have sufficient viscosity to support the load. Gases, of course, have some viscosity.

At the moment, there is a great deal of interest in gas-lubricated bearings. Their main advantages are that the lubricant systems can be simpler and the high temperatures do not harm the lubricant. Owing to the lower viscosity, gas load-carrying capacity is less and clearances are smaller than for liquid lubricants—surface finish and geometry must be very good in order to have reasonable operation.

This also applies to the more conventional liquid-lubricated bearings. Equally important is the journal geometry. Quite often journals are found that are not as round as desired. Actual bearing tests have shown that, in highly loaded journal bearings, a repetitive out-of-roundness of only 50 microin. will increase the wear rate by a factor of 10.

The converging geometry that is so helpful in generating the load-carrying pressure in journal bearings is more difficult to obtain for thrust bearings. A great variety of different thrust-bearing geometries is used to produce the load-carrying fluid film. Fig. 8 shows some typical configurations which are commonly used to produce hydrodynamic load-carrying films. It should be noted that parallel thrust washers have no hydrodynamic load-carrying capacity and they rely on boundary lubrication or "thermal wedges" to support loads.

Load Induced. Bearings in this class have load-carrying capacity by virtue of the manner in which the load is applied. "Load-induced" load-capacity can persist only if there is a reversal of the load direction during the loading cycle. The load-carrying capacity arises because a finite amount of time is required to squeeze the fluid from between the two closely fitted surfaces. The fluid can be

squeezed out rapidly when the clearance is large, but as the journal approaches the bearing, the thinner clearance space retards the escaping of the fluid and the film is stiffer. Relative motion of a bearing and journal is shown in Fig. 9. Obviously, with good geometry and surface finish, the load-carrying capacity becomes very high—much higher than for comparable unidirectionally loaded bearings.

While "load-induced" or dynamically loaded bearings can support extremely high loads, the bearing material is exposed to cyclic loading which may lead to fatigue failure. Materials then must be selected which have sufficient fatigue strength.

Externally Pressurized Bearings

The load-carrying ability of externally pressurized bearings is not dependent upon either the character of the load or the geometry of the bearing; but rather on an external source of fluid under pressure. This type of bearing has been limited to highly specialized applications but is now finding its way into everyday usage. Indeed, the next great advance in precision tools may be made with externally pressurized bearings. These bearings may take many forms and their application is limited only by imagination.

Their operation can be demonstrated by examination of two common types. A simple type of load lift is shown schematically in Fig. 10A. Assume that the movable plates cannot be tilted but can be displaced vertically. The product of the recess pressure p_r and the effective area A_E, which is dependent upon the pressure distribution over the entire pad, must be equal to the applied load if the system is to be in static balance. A restriction in the supply line provides a pressure drop which is a function of the flow rate and permits the recess pressure to be lower than the supply pressure. When there is a pressure drop across the restrictor, there must be a flow from the bearing and the loaded member is lifted from the bearing—the amount of lift being proportional to the cube root of the flow rate. The motion of the loaded member is controlled by two restrictors in series; the first being the restrictor in the line and the second being formed between the loaded member and the lands of the bearing. The flow from the recess may be calculated as flow between parallel plates:

$$Q = (bh^3 p_r)/(12L\mu)$$

With a fixed supply pressure p_s, the bearing performs like a spring; as the load is applied, the clearance **h** is reduced to carry the increased load. The bearing is able to carry the greater load because the smaller clearance reduces the flow through the restrictor—the lower the flow through the restrictor, the higher becomes the recess pressure. This action will continue with further increase in load until the member actually contacts the bearing lands and seals off the flow. The recess pressure then becomes equal to the supply pressure and the limit of load-carrying capacity is reached.

An arrangement often used for journal bearings is shown in Fig. 10B. Here, the pressure pads are used on opposite sides of the shaft and the resistance to radial motion of the shaft with load may be made large. In one application, a system was designed in which 20lb of radial force must be exerted to move a 2-in.-dia shaft 1 microin.

Small tubes or orifices are normally used to provide the hydraulic restriction. These restrictors are selected to provide a particular pressure drop at the flow required by the bearing. With the low flow rates encountered in close-clearance bearings, the restrictors become physically so small that plugging with dirt becomes a serious problem. For example, systems have been designed which use 0.004-in.-ID capillary tubing. There are, however, bearing-restrictor systems which minimize the dirt-clogging problem. Most of these function as the variable-dam restrictor shown in Fig. 10C. Here the flow restrictor is between the bearing and journal surfaces—opposite the pad which is being controlled. Another advantage is that the final restrictor design is not dependent upon the diameteral clearance in the bearing. With conventional capillary or orifice-type restrictors, the calculations must include the design clearance and (for critical application) restrictors can be calculated only after the parts have been manufactured and measured.

Advantages that should make pressurized bearings appeal to machine designers are:

Clearance is maintained regardless of speed. Since clearance is always maintained while the bearings are in operation, they do not wear out and bearing material selection ceases to be a problem. Furthermore, the running center of a workpiece is maintained when the part is stopped for gaging.

At zero velocity there is a zero friction. This relationship makes externally pressurized bearings uniquely suited for use in measuring systems and dynamometers. The nature of the viscous friction of externally pressurized bearings prevents "stick-slip" motion often encountered with machine ways.

The recessed areas reduce friction at high speeds. The friction varies directly with the speed, but since most of the friction occurs in the land area this torque is reduced as the land area is reduced.

Highly stable and vibration free. These features are reflected directly in the quality of the parts made on the machine tool.

They are easily designed. The performance characteristics can be readily determined from relatively simple published relationships. Many design variables give designers great freedom in gaining the performance characteristics which they desire.

The main disadvantage of externally pressurized bearing arises from the fact that an external supply of high-pressure fluid along with the usual pumps, filters, pressure regulators, and sumps must be furnished. These are not commercially manufactured items so they must be designed to fit the particular installation.

REFERENCE:

Which Bearing and Why? by Arnold O. DeHart, Senior Research Engineer, Research Laboratories, General Motors Corporation, Warren, Mich. Paper presented at the 1959 Design Engineering Conference, Philadelphia, Pa. Paper No. 59-MD-12.

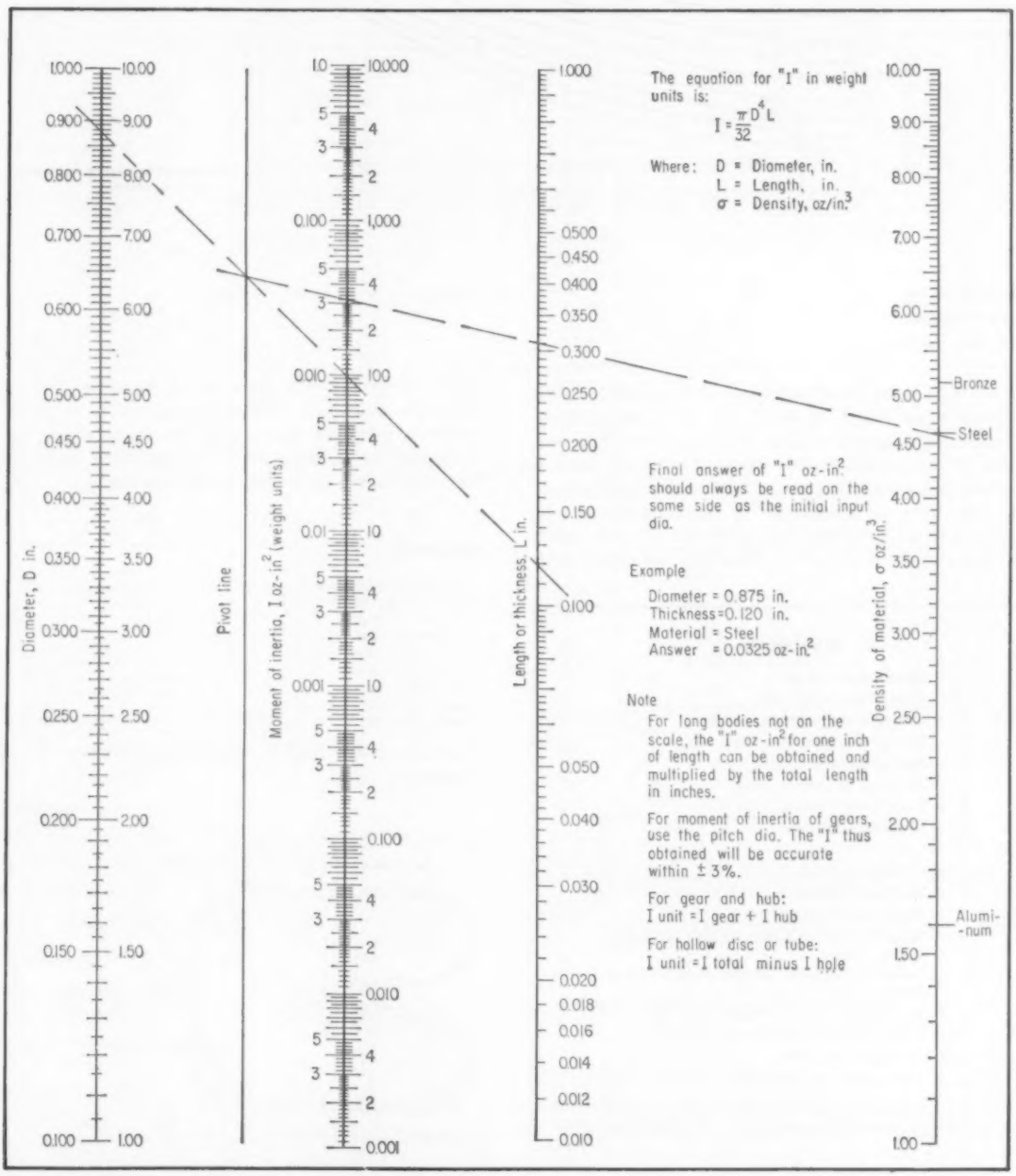
From: Company brochure

MOMENT of INERTIA of cylinders

The moment of inertia I of a body is by definition: that property of a body which for a given torque T determines its angular acceleration α, or $T = I\alpha$. This I must be in mass units of (oz-in-sec^2). The relationship between I_{Weight} and I_{Mass} is: $I_W = I_M \times G$, so that I_W, oz-in^2 = I_M, oz-in-sec^2 × 386 in./sec^2.

REFERENCE:

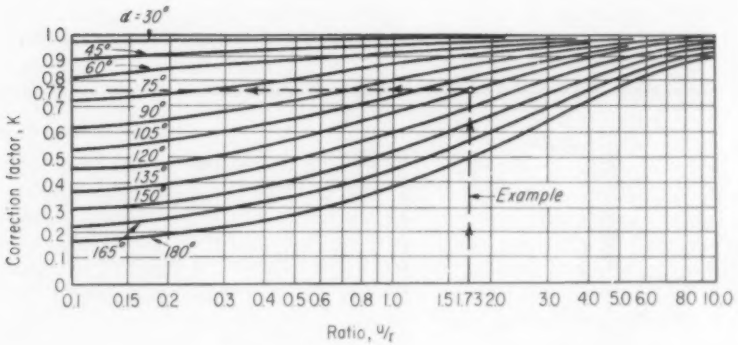
Inertia Conversion Nomograph. Published by Reeves Instrument Corporation, 215 East 91st Street, New York 28, New York.


Diameter, D in.
Pivot line
Moment of inertia, I oz-in² (weight units)
Length or thickness, L in.
Density of material, σ oz/in.³
Bronze
Steel
Alumi-num
The equation for "I" in weight units is:
I = π/32 D⁴ L
Where: D = Diameter, in.
L = Length, in.
σ = Density, oz/in.³
Final answer of "I" oz-in² should always be read on the same side as the initial input dia.
Example
Diameter = 0.875 in.
Thickness = 0.120 in.
Material = Steel
Answer = 0.0325 oz-in²
Note
For long bodies not on the scale, the "I" oz-in² for one inch of length can be obtained and multiplied by the total length in inches.
For moment of inertia of gears, use the pitch dia. The "I" thus obtained will be accurate within ± 3%.
For gear and hub:
I unit = I gear + I hub
For hollow disc or tube:
I unit = I total minus I hole

From: VDI-Zeitschrift

DESIGN EQUATIONS FOR CURVED SPRINGS

How spring force, deflection and stress can be calculated with greater accuracy.



CORRECTION FACTORS for curved springs

JOACHIM PALM
KLAUS THOMAS
Munich, West Germany

Curved springs are usually designed with equations based on the stretched length of the spring, disregarding curvature influence. These equations are inaccurate. The new method retains simplicity but gains accuracy by using a correction factor for curvature. Test results agree closely with deflections as calculated by these formulas; for example, a type D spring (see table below) was calculated within 8% of its actual deflection and stress compared to over 100% error when formulas that ignore curvature were used. Curved spring shapes are tabulated below as five basic types—complex spring shapes can be computed by splitting them up into their basic shapes. This approach is illustrated in the example.

Symbols

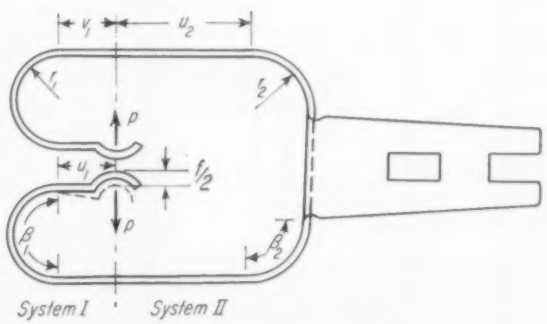
b = Spring width, mm
D = Spring diameter, mm
E = Young's modulus, kg/mm²
F = Spring displacement, mm
h = Spring thickness, mm
I = Moment of inertia, mm⁴
K = Correction Factor
L = Moment arm, mm
m = u/r
P = Spring force, kg
r = Radius of curvature, mm
S = Section modulus, mm³
u = Length of straight section at free end of spring, mm
v = Length of straight section at fixed end of spring, mm
α = Parameter for plotting K, degrees
β = Angle of spring curvature, radians
λ = Moment arm, mm
σ = Maximum bending stress, kg/mm²

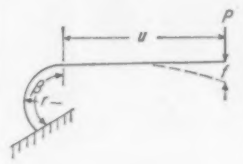
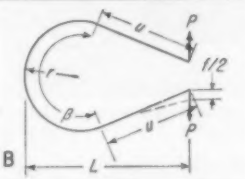
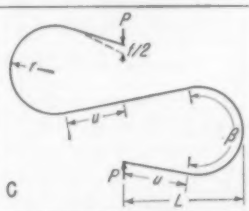
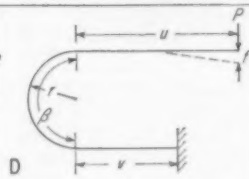
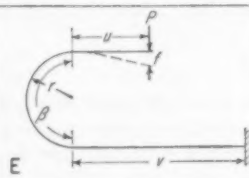
For accurate results h/r for flat springs or D/r for round wire springs should be less than 0.6.

EXAMPLE:

E = 14,500 kg/mm²
σ_{max} = 55 kg/mm²
b = 1.20 mm
h = 0.30 mm
r_1 = 0.65 mm
r_2 = 1.75 mm
L = 9.7 mm
u_1 = 1.7 mm
u_2 = 5.6 mm

Find maximum load P, maximum deflection F, spring constant C.



SPRING TYPE	SPRING DEFLECTION	SPRING FORCE AND BENDING STRESSES
 A	$F_1 = \frac{KPr^3}{3EI}(m+\beta)^3$ Where $\alpha = \beta$ for finding K	When $\alpha = 0°$ to $90°$: $P = \frac{S\sigma}{u+\sin\beta}$, $\sigma = \frac{Pr(m+\sin\beta)}{S}$ When $\alpha = 90°$ to $180°$: $P = \frac{S\sigma}{u+r}$, $\sigma = \frac{Pr(m+1)}{S}$
 B	$F_2 = \frac{2KPr^3}{3EI}(m+\frac{\beta}{2})^3$ Where $\alpha = \frac{\beta}{2}$ for finding K	$P = \frac{S\sigma}{L}$ $\sigma = \frac{PL}{S}$
 C	$F_3 = 2F_2 = \frac{4KPr^3}{3EI}(m+\frac{\beta}{2})^3$ Where $\alpha = \frac{\beta}{2}$ for finding K	
 D	$F_4 = F_5 = \frac{P}{3EI}\left[2Kr^3(m+\frac{\beta}{2})^3 + (v-u)^3\right]$ Where $\alpha = \frac{\beta}{2}$ for finding K	$P = \frac{S\sigma}{\lambda} = \frac{P\lambda}{S}$
 E		

First condition	Second condition	λ
$u \geq v$	---	$u+r$
$u < v$	$(u-v) < (u+r)$	$u+r$
$u < v$	$(v-u) > (u+r)$	$v-u$
$u = 0$	$v \leq r$	r
$u = 0$	$v > r$	v

SOLUTION:

Split the spring into two systems. System I is type D; System II is type A. Spring force $P = P_I = P_{II}$

Since $u_2 + r_2 > u_1 + r_1$

$$P = \frac{S\sigma_{max}}{u_2 + r_2}$$

Substituting: $S = \frac{bh^2}{6}$

$$P = \frac{bh^2\sigma_{max}}{6(u_2 + r_2)} = 0.135 \text{ kg}$$

Deflection $F = 2(F_I + F_{II})$

$$F = \frac{2P}{3EI}\left[2K_1r_1^3\left(m_1 + \frac{\beta_1}{2}\right)^3 + (v_1 - u_1)^3 + K_2r_2^3(m_2 + \beta_2)^3\right]$$

Substituting: $I = \frac{bh^3}{12} = 0.0027 \text{ mm}^4$

$$F = \frac{2 \times 0.135}{3 \times 14.5 \times 10^3 \times 2.7 \times 10^{-3}}[2 \times 0.92 \times 0.65 (2.62 + 1.57)^3 + 0 + 0.94 \times 1.75^3 (3.2 + 1.57)^3] = 1.34 \text{ mm}$$

Spring constant $C = \frac{P}{F} = 0.101$ kg/mm.

REFERENCE:

Design Equations for Curved Springs by Joachim Paul and Klaus Thomas, Munich, W. Germany. Published by VDI-Zeitschrift, 1959, No. 8, p. 301-308.

From: ASME paper

designing products for AUTOMATIC ASSEMBLY

7 important areas of design that can lead to simpler and less costly automatic assembly.

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Supervisor, Engineering and Sales Application
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The rise of automotive, appliance and other mass-production industries brought about a switch from hand to automatic assembly. To adapt previously hand-assembled products to automatic assembly the designer adds features that aid mechanical conveying, feeding, positioning and fitting. Adding features adds costs, but the large-scale economies of automatic assembly make the product cheaper in the end. Although automatic assembly is cheaper and faster, quality does not suffer, but improves.

Workers may fear the loss of jobs because of automatic machinery, but they receive a direct benefit. Assembly machines, which reproduce man's senses of sight and touch, relieve workers of dull, repetitive operations.

1 Part Handling

Hand feeding rather than hoppers or magazines is used with extremely large parts. In hoppers or magazines large parts damage each other by jostling, and take up too much space, if the supply is to last at least a half hour.

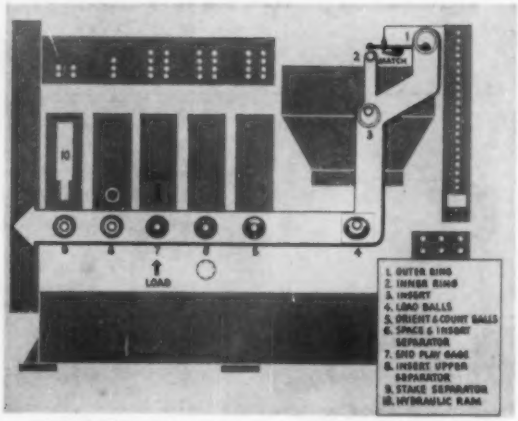
The designer must guard workers against the monotony of hand feeding. If the worker must think each time he puts a part in the machine, he becomes tired, his efficiency drops, and he can cause damage to the machine or part. Aids like a protrusion or hole allow him to load by relying solely on his sense of touch and his subconscious.

Other design details help the worker. Shaping the part so that it doesn't tangle with others allows him to pick the part out of the bin easily. Removing burrs and rounding edges enables him to wear thin gloves or use bare hands.

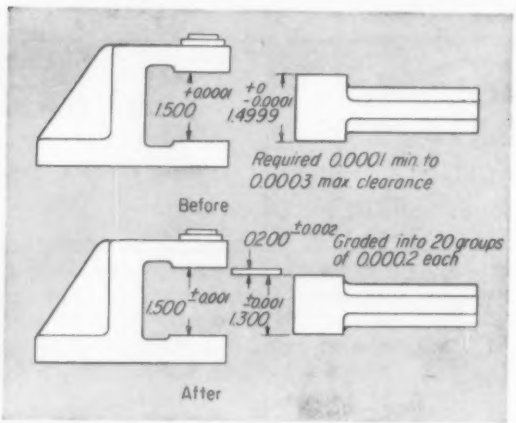
Magazines are both fast and safe. They are fast enough to keep up with high-speed machines, and are safe because they can be hand-loaded well away from the machine.

Some parts are difficult to handle. It is often easier to complete the last manufacturing step in the assembly machine than to handle the completely finished part. For example, wire for retaining rings is wound on a mandrel that is loaded into the machine. As the wire feeds off the mandrel, the assembly machine cuts it into individual rings.

Thin stampings such as leaf springs, contact arms, gaskets, and shims are stamped in a continuous strip without separation. The strips are wound in a coil and loaded in the magazine. During assembly a blade cuts parts from the strip.



1. SCHEMATIC of ball-bearing assembly machine that matches clearance between inner and outer ring with correct-size ball.



2. ADDITION OF SHIM-WASHER allows assembly of clevis and yoke by selective fitting.

Hoppers give completely automatic feed.

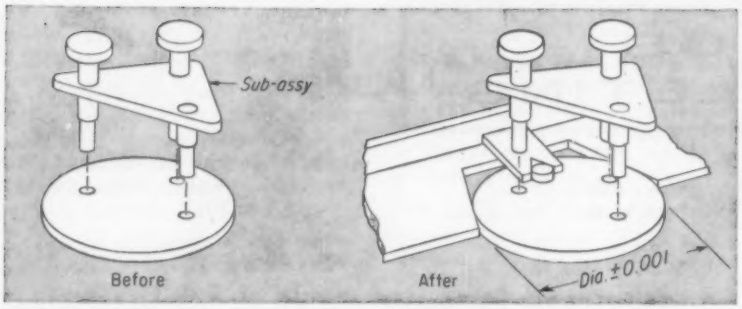
A part must position itself as it feeds by gravity from a hopper. The engineer designs the part with off-center weight distribution, lugs or slots so that it will take the position he wants. Cylindrical parts position more consistently if they have a length 25% or more longer or shorter than the diameter.

It is only probable, not positive, that the parts from a gravity feed hopper will line up right. The machine must have a system built in to reject those parts that don't line up correctly.

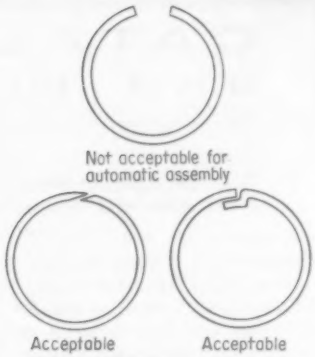
With any kind of mechanical feed or conveyor removing burrs and rounding edges cuts machine down time caused by jammed parts.

2 Product Tolerances

Tolerances acceptable for product performance and appearance may not be acceptable for automatic assembly.



3. REDESIGN OF PLATE makes positioning easier.



4. ALTERED RETAINING RINGS don't tangle during feeding.

Outside dimensions that vary widely will not affect performance or appearance of a pushbutton. But when pushbuttons are automatically assembled to tuner shafts, they must be precisely aligned. Since alignment is made from the outer diameter of the pushbutton, the designer must tighten tolerances.

3 Selective Fitting

When tolerances for the final assembly are close, selective fitting allows less expensive, wider tolerances on individual parts. Automatic gaging inspects A-parts and distributes them in racks or magazines according to size. When the mating B-part enters the machine, it also is gaged. A size signal causes a proper size A-part to drop out of the racks for assembly.

Let's see how this works with ball-bearings. In this case three parts—inner ring, outer ring and balls—have to fit with a minimum clearance of 0.0004 in. and a maximum clearance of 0.0008 in. It is difficult to hold ring tolerance less than ±0.001 in. But ball size can be controlled to ±0.000025 in., so twenty-one different sizes in steps of 0.000050 in. are made. Each size goes in a separate hopper. The first station in the assembly machine inspects both inner and outer rings simultaneously to determine which of the twenty-one groups of balls gives a correct assembled clearance, Fig. 1.

Some assemblies do not have a part which can be sized as closely as the balls. The engineer must change the design to provide one. The redesign of the yoke and clevis in Fig. 2 has an extra part, a washer, that is easily machined to close tolerances and allows yoke and clevis tolerances to be much greater.

4 Positioning

For positioning, a part must have an accurately dimensioned surface. Usually the designer specifies close tolerances only for those surfaces involved in a fit. These are the surfaces that are most likely being assembled to, so they cannot be used for positioning at the same time.

Fig. 3 illustrates such a problem. A flat, round wafer has three accurately machined holes that cannot help position the wafer, because three shafts fit into them. The solution: An additional knob and closer tolerances on the wafer's outer diameter. Other common answers to such a problem are a notch, protrusion, locating holes, machined surfaces, tabs or ears.

A different approach is to chamfer the shaft holes, reducing necessary positioning accuracy and also reducing chances of jamming.

Assembly machines must be able to detect the presence of parts at each station so that they will not try to assemble the rest of the parts at an empty station. Photoelectric cells are suited for detecting small, lightweight parts.

During assembly of one product, a small washer, so thin that light passed through it, had to be detected for presence. By changing the washer from natural to a dark color, the designer adapted it for photoelectric detection.

5 Manufacture During Assembly

Simple parts like shims, gaskets, washers and springs are easy to make. By manufacturing parts like these right in the assembly machine, handling is eliminated. This method is especially handy for springs, because they are so difficult to handle and feed automatically.

One example of this method is in the assembly of diaphragm linkages for automobile distributors. Operators load the machine with rolls of strip stock instead of finished diaphragms. Two die stations punch out diaphragms from the strip stock.

6 Fastening

Rivets and staking fit automatic assembly best because they do not require any additional screws, nuts or snap rings. Devices on the assembly machine for riveting and staking are simple and easy to maintain, while those for feeding and driving screws are intricate. Snap rings and retaining rings work if designed to keep them from tangling. See Fig. 4.

7 Finishes

Tumbling, vibrating or abrading during automatic feeding is hard on finishes, especially painted surfaces. If the part must be painted, and can't be painted after assembly, use magazine or hand feeding.

REFERENCE:

Designing Products for Automatic Assembly by Robert L. Esken, Supervisor, Engineering and Sales Application, Autometrology Section, Sheffield, Corp, Subsidiary of Bendix Aviation Corp, Dayton, Ohio. Paper presented at ASME Design Engineering Conference, New York City, May 1960. Paper No. 60-MD-12.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(F-1) Ball Bearing Units—Catalog, 8 pp. Describes prelubricated ball bearing package units in such forms as sprocket and belt idlers. Aetna Ball & Roller Bearing Co, 4600 W Schubert Ave, Chicago 39.

(F-2) Aluminum Bearings—Two bulletins, 91 pp. Many curves, tables and charts give design information and results of tests. Subjects include clearances, temperatures, expansion, corrosion and others. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19.

(F-3) Powdered Metallurgy Products—Catalog, 56 pp. Explains how to determine whether application is suitable for powdered metal bearings, filters or other parts. Lists stock self-lubricating bearings. Amplex Div, Chrysler Corp, 6501 Harper, Detroit 31.

(F-4) Springs—Brochure, 8 pp. Provides curves, formulas and charts to aid in spring selection and design. Associated Spring Corp, Bristol, Conn.

(F-5) Strain Gages—Catalog, 24 pp. Lists specifications and prices for bonded wire and foil strain gages, instruments and accessories. Also dimension drawings and criteria for making choice. Electronics & Instrumentation Div, Baldwin-Lima-Hamilton Corp, 42 Fourth Ave, Waltham, Mass.

(F-6) Spring Pins—Catalog, 10 pp. Discusses adavantages, gives sizes and shear strengths for pins 1/32 to 3/4 in. OD. C E M Co, Inc, 24 School St, Danielson, Conn.

(F-7) Worm Gear Jacks—Brochure, 8 pp. Provides dimensioned drawings, illustrations of applications for jacks, mitre gear boxes rated 2 to 100 tons. Duff-Norton Co, Box 1889, Pittsburgh 30.

(F-8) Instrument Gears and Differentials—Catalog, 128 pp. Presents tables of specifications and dimensions of precision, fine pitch gears; clutches, worms and shafting. Dynamic Gear Co, Inc, 175 Dixon Ave, Amityville, NY.

(F-9) Pressure Transducers—Catalog, 14 pp. Provides discussion of subject in general plus individual specifications for pressure, differential pressure, force transducers of strain gage type. Dynisco, Inc, 42 Carleton St, Cambridge, Mass.

(F-10) Sleeve Bearings—Brochure, 18 pp. Gives materials properties, standard sizes and design guides. Federal-Mogul Div, 11031 Shoemaker Ave, Detroit 13.

(F-11) Formed Bushings—Brochure, 25 pp. Includes materials, sizes, design data and applications. Federal-Mogul Div. 11031 Shoemaker Ave, Detroit 13.

(F-12) Thrust Washers—Brochure, 10 pp. Discusses materials, standard sizes and possible shapes. Federal-Mogul Div, 11031 Shoemaker Ave, Detroit 13.

(F-13) Spindles—Bulletin, 4 pp. Describes cartridge type spindle assemblies up to 2.750 in. diameter with five spindle nose configurations. Russell T Gilman, Inc, 624 Beech St, Grafton, Wisc.

(F-14) Dovetail Slides—Catalog, 24 pp. Describes manual and cylinder or cam positioned slides up to 8 in. widths. Used for positioning, feeding or inspection. Russell T Gilman, Inc, 624 Beech St, Grafton, Wisc.

(F-15) O-rings—Handbook, 52 pp. Presents data on o-ring design, sizes, installation and recommended practice. Goshen Rubber St, Inc, 2090 South St, Goshen, Ind.

(F-16) Coiled Flat Springs—Brochure, 16 pp. Describes spring form that gives constant force, and illustrates uses. Hunter Spring Co, Lansdale, Pa.

(F-17) Bearings—Brochure, 8 pp. Illustrates facilities of company; range of bearing and bushing line. Johnson Bronze Co, S Mill St, New Castle, Pa.

(F-18) Self-lubricating Bearings—Catalog, 44 pp. Contains design data, composition, tables of dimensions for porous bronze and porous iron bearings. Keystone Carbon Co, 1935 State St, St Marys, Pa.

(F-19) Needle Bearings—Catalog, 140 pp. Give dimensions, ratings, lubrication requirements for caged, uncaged, center guided, double row types, and cam followers. Includes engineering section for choosing correct bearings. McGill Mfg Co, Inc, Valparaiso, Ind.

(F-20) Vibration Pickups—Brochure, 4 pp. Two miniaturized models cover frequency range from 8 to 2000 cps. Vibration meters also shown. MB Electronics, 781 Whalley Ave, New Haven, Conn.

(F-21) Disc Springs—Handbook, 44 pp. Presents curves, tables, fromulae and design procedure for choosing correct spring. Includes table with sizes and characteristics summarized. Karl A Neise, Inc, 404 Fourth Ave, NYC.

(F-22) Roller Bearings—Catalog, 44 pp. Shows construction, ratings, dimensions of roller, needle, thrust roller bearings, and cam followers. Also tolerances and fits. Orange Roller Bearing Co, Inc, 557 Main St, Orange, NJ.

(F-23) Automotive Brakes—Brochure, 6 pp. Describes air or hydraulically actuated drum brake for trucks, busses. Lining areas to 220 sq in. Rockwell-Standard Corp, Brake Div, Ashtabula, Ohio.

(F-24) Gears—Catalog, 36 pp. Discusses gear design and encloses tables and curves of design interest. Shows manufacturing and inspection methods and equipment. Sier-Bath Gear & Pump Co, 9211-A Hudson Blvd, N Bergen, NJ.

(F-25) Self-aligning and Rod End Bearings—Catalog, 36 pp. Gives tables of dimensions and load ratings. Southwest Products Co, 1705 S Mountain Ave, Monrovia, Cal.

(F-26) Pillow Blocks—Catalog, 40 pp. Gives applications, dimensions of sleeve type, self-aligning pillow blocks which mount in several different ways. Triangle Mfg Co, 730 Division St, Oshkosh, Wisc.

(F-27) Vibration Isolators—Brochure, 4 pp. Gives sizes and performance curves for all-metal mounts. Load ratings go up to 35 pounds. Ucinite Co, Div of United-Carr Fastener Corp, 459 Watertown St, Newtonville, Mass.

(F-28) Bearing Balls—Bulletin, 4 pp. Provides data on balls from 0.0625 to 0.750 in. Also burnishing media and decorative shapes. The Abbott Ball Co, Railroad Ave, Hartford, Conn.

(F-29) Springs—Brochure, 40 pp. Furnishes formulas, tables and discussion to enable designing with compression, extension and torsion coil springs. Accurate Spring Mfg Co, 3811 W Lake Ave, Chicago 44.

(F-30) Adjustable Bushings—Brochure, 16 pp. Provides sizes and design guides for bushing assembly with adjustable wall thickness for use around bolts and as a bearing. Adjustable Bushing Co, 12035 Vose St, N Hollywood, Cal.

(F-31) Metal O-rings—Catalog, 11 pp. Furnishes resiliency graphs, dimensional tables, uses and description of different

types. The Advanced Products Co, 59 Broadway, North Haven, Conn.

(F-32) Filters—Catalog, 8 pp. Presents large and small air, oil and fuel filters, plus vents, spark arresters. Air-Maze Corp, 25000 Miles Rd, Cleveland 28.

(F-33) Environmental Test Equipment—Catalog, 12 pp. Describes apparatus for simulating conditions of altitude, temperature, humidity, sand and dust, rain, sunshine and others. American Research Corp, Farmington, Conn.

(F-34) Airborne Tape Recorder—Brochure, 12 pp. Data recorder transports at up to 60 ips with choice of four different recording techniques. Ampex Data Products Co, 934 Charter St, Redwood City, Cal.

(F-35) Wideband Tape Recording—Brochure, 6 pp. Tape recorder range is 10 cps to 40 mc. Protection provided for low pressure and high temperature environments. Ampex Data Products Co, 934 Charter St, Redwood City, Cal.

(F-36) Data Tape Recorder—Brochure, 12 pp. Analog magnetic tape recorder-reproducer operates at 7½ ips to 60 ips. Direct, fm and pdm recording available. Ampex Data Products Co, 934 Charter St, Redwood City, Cal.

(F-37) Environmental Testing—Brochure, 8 pp. Outlines facilities available including acceleration, shock, vibration, noise plus environmental equipment. Associated Testing Laboratories, Inc, Clinton Rd, Caldwell, NJ.

(F-38) Environmental Test Chambers—Bulletin, 16 pp. Describes machines for simulating temperature, pressure, noise, shock, vibration, other conditions. Associtated Testing Laboratories, Inc, Clinton Rd, Caldwell, NJ.

(F-39) Instruments—Catalog, 24 pp. Gives specifications for instruments and accessories for measuring sound, vibration and strain. Some instruments of recording type. B & K Instruments Inc, 3044 W 106 St, Cleveland.

(F-40) Mechanical Instruments—Catalog, 14 pp. Describes tachometers, counters and instrument drive cables, clutches and gear boxes. Barbour Stockwell Instruments, 80 Cambridge St, Worcester 3, Mass.

(F-41) Ball Bearings—Bulletin, 4 pp. Shows materials, dimensions, performance of high speed bearings with phenolic and aluminum retainer. Bore sizes to over 1.7 in. The Barden Corp, 212 Park Ave, Danbury, Conn.

(F-42) Chart Drives—Bulletin, 10 pp. Provides application details for use of multiple speed chart drives with several makes of chart recorders. Insco Co, Div of Barry Controls Inc, Hollis St, Groton, Mass.

(F-43) Instrument Speed Reducer—Catalog, 7 pp. Provides specifications, dimensions and applications of eight and ten ratio step function speed reducers. Insco Co, Div of Barry Controls Inc, Hollis St, Groton, Mass.

(F-44) Levers and Mechanical Control Units—Brochure, 13 pp. Illustrates and dimensions stock and special drop forged and fabricated products. Batavia Metal Products Corp, Box 339, Batavia, NY.

(F-45) Ball Bearings—Catalog, 102 pp. Subjects discussed include bearing load determination, lubrication, shields and seals. Tables, graphs and text describe radial, angular contact, thrust and other type bearings. Bearings Co of America, 13836 Puritan, Detroit 27.

(F-46) Laboratory Equipment—Catalog, 12 pp. Describes such instruments as spectrophotometers, gas chromatographs, oxygen analyzers, pH meters. Scientific & Process Instruments Div, Beckman Instruments, Inc, 2500 Fullerton Rd, Fullerton, Cal.

(F-47) Roller Bearings—Catalog, 30 pp. Provides dimensions, ratings and selection data for bearings. Bearings come in size range to fit over shafts from ⅛ to 2⅞ in. diameter. Berliss Bearing Co, 644 W Mt Pleasant Ave, Livingston, NJ.

(F-48) Removable Truck Bodies—Two bulletins, 18 pp. Describes system with truck mounted hoist which loads and unloads detachable containers. Ingersoll Kalamazoo Div, Borg-Warner Corp, 760 E Vine St, Kalamazoo, Mich.

(F-49) Porous Bronze Bearings—Brochure, 19 pp. Furnishes lists of bearing sizes plus load curves, machining instructions and physical properties of oil retaining bearings. Bound Brook Oil-Less Bearing Co, Bound Brook, NJ.

(F-50) Instruments—Brochure, 8 pp. Explains construction, specifications of pressure or angular position transducers, accelerometers, linear potentiometers. Bourns, Inc, Instrument Div, 6135 Magnolia Ave, Riverside, Cal.

(F-51) Slip Ring Assemblies—Catalog, 26 pp. Describes standard and custom assemblies for instrumentation, rotating antennas, switching. Breeze Corporations, Inc, 700 Liberty Ave, Union, NJ.

(F-52) Thermocouples—Bulletin, 4 pp. Describes sizes, materials and configurations for different purposes. Thermocouples are insulated with ceramics and sheathed in metal. The Bristol Co, Waterbury 20, Conn.

(F-53) Bearing Units—Catalog, 18 pp. Contains load ratings and specifications for pillow blocks, flange blocks and take-up units. Browning Mfg Co, Maysville, Ky.

(F-54) Machine Mounts—Brochure, 4 pp. Describes mounts for levelling and for reducing vibration. Gives dimensions and load capacities. Bushings, Inc, 4358 Coolidge Hwy, Royal Oak, Mich.

(F-55) Bushings and Mountings—Brochure, 4 pp. Achieving flexibility through rubber, these parts are used to absorb vibration and shock. Bearing assemblies and couplings included. Bushings, Inc, 4358 Coolidge Hwy, Royal Oak, Mich.

(F-56) Rubber-metal Parts—Catalog, 12 pp. Describes bearings, bushings, mounts, sleeves, and magnetic rubber for recording. Clevite Harris Products, Inc, Lockwood, Rd, Milan, Ohio.

(F-57) Sensing Devices—Catalog, 16 pp. Describes sensing devices for industry, the military, research. Includes force-balance instruments, primary pressure standard, accelerometers, pressure and vibration transducers. Transducer Div, Consolidated Electrodynamics Corp, 360 Sierra Madre Villa, Pasadena, Cal.

(F-58) Journal Bearings—Catalog, 4 pp. Describes tilting shoe type bearing designed to eliminate vibration. Sizes for shafts from 2 to 12 in. diameter. Waukesha Bearings Corp., Box 346, Waukesha, Wisc.

(F-59) High Speed Cameras—Brochure, 4 pp. Explains operation of camera for taking up to 16,000 frames per second. Also shows accessories. Wollensak Optical Co, 850 Hudson Ave, Rochester, NY.

(F-60) Panel Instruments—Bulletin, 6 pp. Provides ranges, scales, other data for ammeters and voltmeters for a variety of uses. Daystrom, Inc, Weston Instruments Div, 614 Frelinghuysen Ave, Newark, NJ.

(F-61) Blower Housings—Brochure, 18 pp. Provides dimensioned drawings of housings and accessories for wheels from 3 to 11 in. Detroit Stamping Co, 350 Midland, Detroit 3.

(F-62) Roller Bearing Bushings—Catalog, 6 pp. Gives specifications of bushings for jig and fixture piloting and milling machine arbor supports. Donley Products, Inc, 11106 Avon Ave, Cleveland 5.

(F-63) Analog Computer—Brochure, 20 pp. Computer has 3450 hole prepatch panel for programming. Design expands through use of many additional components. Electronic Associates, Inc, Long Branch Ave, Long Branch, NJ.

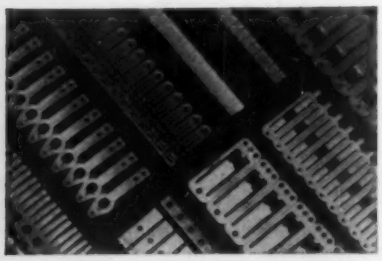
continued

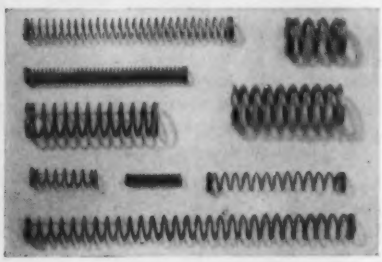
I-S SPRINGS of beryllium copper *can help you*

IMPROVE YOUR PRODUCT'S QUALITY, REDUCE YOUR COST, INCREASE YOUR PRODUCTION

Instrument Specialties Company specializes in the design and custom manufacture of age-hardened alloy springs. With our specially developed processes and machines, our engineers are able to realize the fullest performance potential from the superior spring materials around which I-S service to designers and manufacturers has been developed.

FOR HIGH PRODUCTION





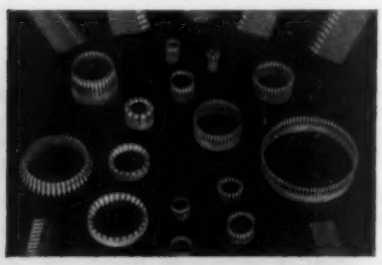
STRIP SPRINGS

Fabricated from beryllium copper.
Easily handled, readily broken apart by hand or used in automatic or semi-automatic assembling devices and contact riveting machines.
Individual pieces may be broken off without trace of burr.
Eliminate sorting, untangling and handling of loose pieces.
Springs may be produced in strips to various shapes; formed angles may be held within plus or minus one degree.
Heat treated in multiple fixtures to insure uniformity, close tolerances and elimination of variations in spring-back.

COIL SPRINGS

Made from laboratory tested beryllium copper wire. Special coiling and heat treating equipment insures 100% uniformity.
Guaranteed rigid tolerances held on diameter and load tests at specified deflection.
These factors combine to assure increased service life through higher endurance strength – make products perform more consistently by eliminating drift, set or fatigue. Furthermore, they eliminate expensive hand adjustment and reduce inspection costs of finished product.

FOR LOW ACTIVITY



HIGH FREQUENCY SPECIALTIES

We are equipped to supply standard mating parts for use with 2C-39, 2C-40, 2C-43 and 3C-37 tubes, or custom made parts in related fields.
Grounding strips and contact fingers can be supplied in standard or special contours.
"Flea" contacts for co-planer type subminiature tubes and transistors.

SHORT-RUN SERVICE

For those who need quick delivery of parts in pilot quantities or require a low-cost proving ground for spring designs. I-S methods eliminate expensive tooling. Laboratory controlled, precision produced—yet at lower cost than is possible with permanent, high-activity tools.
We are equipped to handle conventional beryllium copper stampings and screw machine products in short runs or in high production.

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INSTRUMENT SPECIALTIES CO., INC.

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A COMPLETE ENGINEERING AND SAMPLE SERVICE

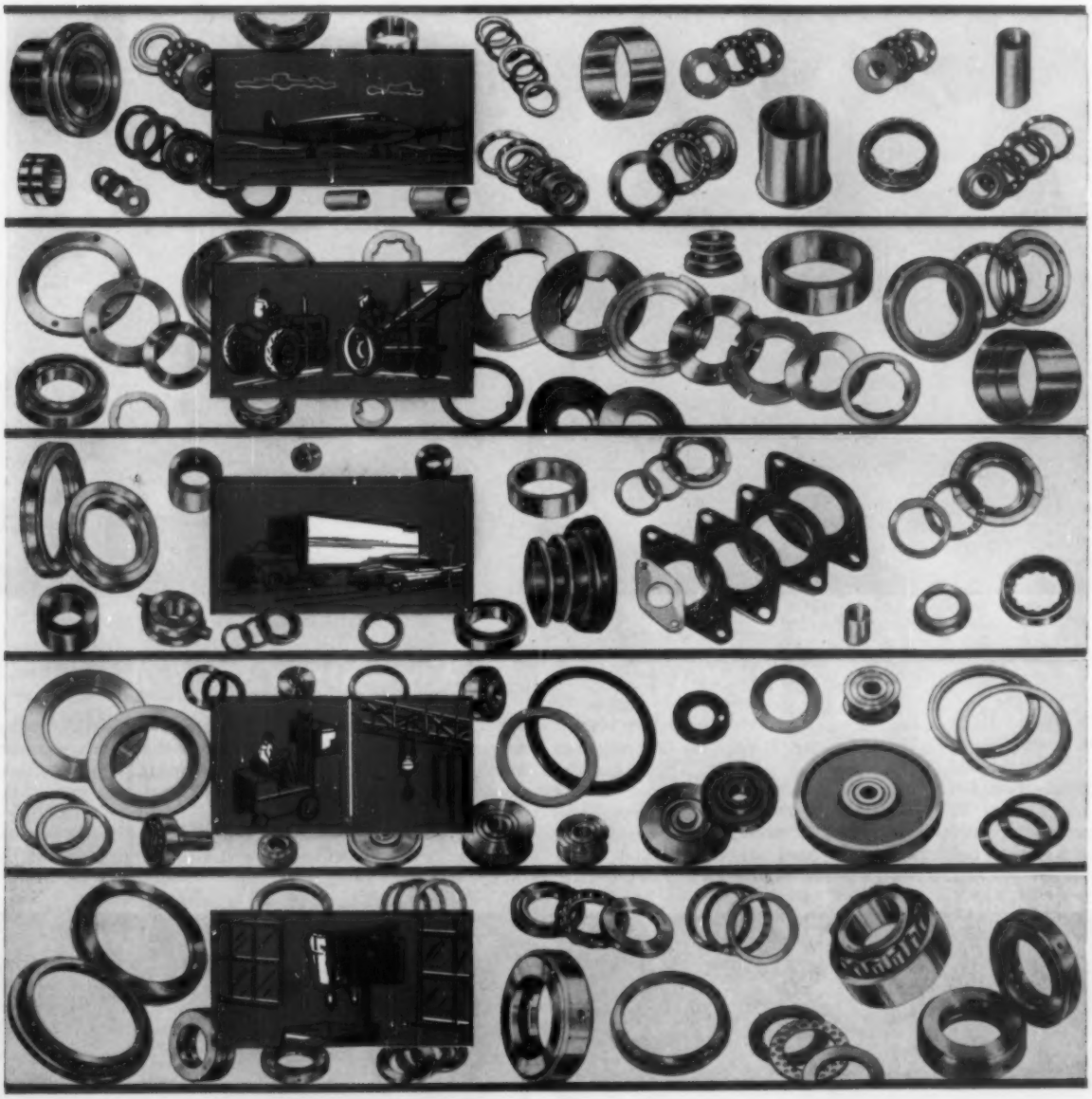
When your product is in the design stage, let us show you how I-S springs of beryllium copper may be designed to fit your needs. Ample stock, flexible facilities, short set-up time speed production of sample lots and trial orders.

Solving difficult Bearing and Special Parts Problems–

an Aetna Specialty

The challenge of new and unusual problems is of continuous interest to Aetna design and application engineers. Their readiness to accept the difficult has established Aetna as a leading source for specially engineered or hard-to-make bearings, and hardened and ground precision parts.

Whatever your problems may be, the Aetna engineering facilities for design and application are available to assist you. Why not outline your anti-friction or parts problems for Aetna study, consideration, and recommendations on how to best achieve operational efficiency and long life expectancy in your products.



Aetna

AETNA BALL and ROLLER BEARING COMPANY
DIVISION OF PARKERSBURG-AETNA CORPORATION

4600 SCHUBERT AVE.
CHICAGO 39, ILL.

ANTI-FRICTION SUPPLIERS TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916

CIRCLE 293 ON READER SERVICE CARD 293

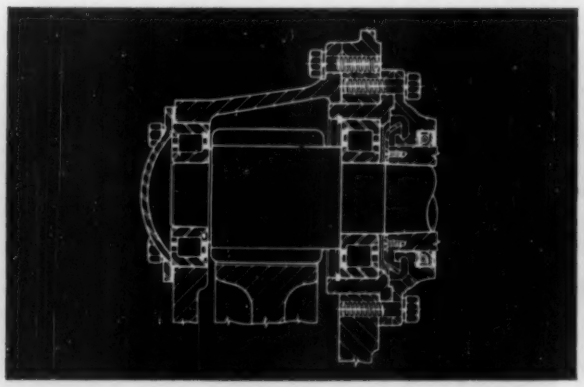
YOU KNOW YOU'VE WHEN YOUR

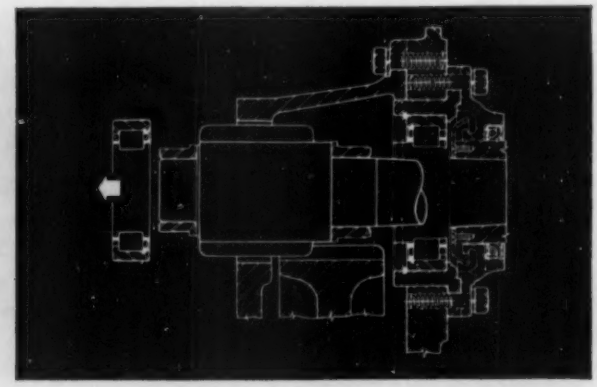
SIMPLIFY AND SAVE

A second look at the very same shaft shows how easy it is to "design in" a Hyatt bearing. It requires no costly end clamps, threads, nuts, screws or washers. That's because Hyatt Hy-Roll bearings can be affixed to the shaft with a heavy press fit. Rest assured, they'll never come loose because Hyatt Hy-Roll races are made from case-hardened, carburizing type steel. The hard outer case and tough ductile core permit heavier press fits without fear of cracking.

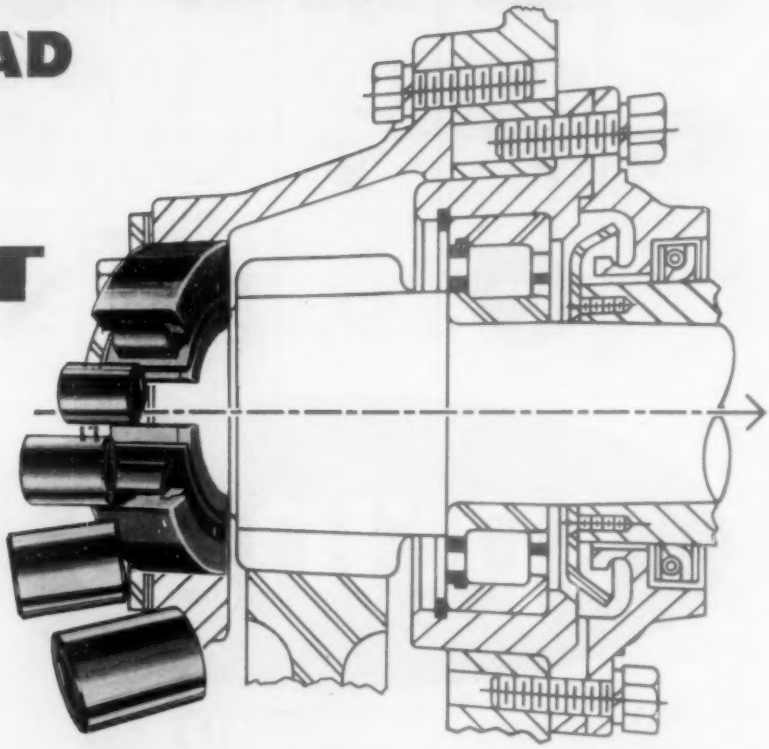
EXPEDITE ASSEMBLY

When a product is assembled, you can see why Hyatt makes all separable races interchangeable within the same part number. For it allows you to press the inner race on the shaft at one work station, then later fit it into any of the mating assemblies already installed in the housing. You don't have to worry about matched assemblies because Hyatt has made selective fitting unnecessary. Think of the time it saves!





PUT THE SHAFT IN ITS PLACE "SPECS" READ HYATT



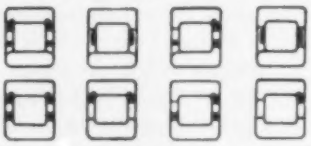
DO BOTH JOBS AT ONCE

Remember how versatile Hyatt Roller Bearings can be. Primarily, they're designed for the heaviest radial loads. But, with shouldered races, they'll also accommodate a considerable amount of thrust load . . . enough to provide adequate shaft location.

Here, for example, is a spur gear drive pinion on an opposed pair of R-YS type Hyatt Hy-Roll Bearings. Shoulders on the inner and outer races restrict lateral movement without sacrificing any of the high load carrying capacity inherent to cylindrical roller bearings. Thus, Hyatt gives you a bearing combination that combines high radial load carrying capacity with convenient shaft location.

You're assured smooth, trouble-free performance the minute you specify Hyatt Hy-Roll Bearings. For Hyatt quality is constantly checked and electronically controlled to insure that the last Hyatt Hy-Roll is every bit as accurate as the first.

Hyatt produces 10 major bearing types—four have separable inner races



—four non-separable

—and two have separable outer races.

The separable race can be omitted and rollers operated directly on the shaft or in the housing bore, in instances where the shaft or housing bore can be suitably hardened and ground.

For full details on selection and application of these bearings see Hyatt Catalog 150 or call your nearest Hyatt Sales Engineer.

Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey

HYATT HY-ROLL BEARINGS

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM RELIABILITY

Belleville

Compression

Conical

Die

Discs

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Flat

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and other things

custom-made to quality standards

Answer your "where to get it" questions– by calling on the versatile experience represented by these typical springs and stamped parts. Here is unusual ability to analyze your part from both design and production efficiency and to make cost-saving contributions where possible. Whether your requirements are large or small, routine or extreme precision, you'll get a better brand of service and quality from the best springmakers in the business.

Send for "Pocket Guide to Springs and Other Things" —a quick picture of our products and services.

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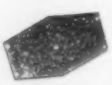
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6003

Associated Spring Corporation

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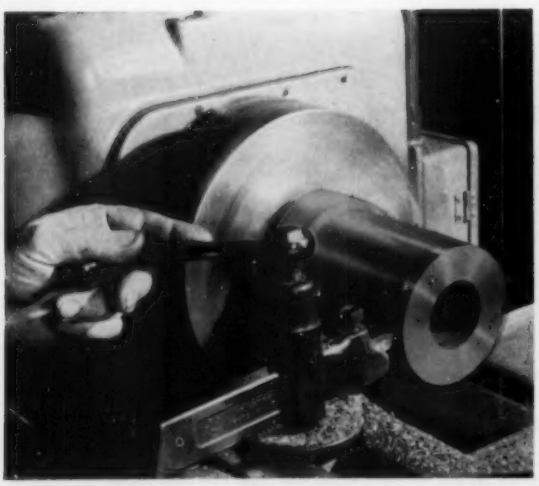
FOR NEW DESIGNS, PROTOTYPES, EMERGENCY REPAIRS...

OILITE

bronze bearing material

- **Solid Bar Stock**
  (6½″ Lengths: ¼″ up to 12⅞″ Diameter)
- **Cored Bar Stock**
  (6½″ Lengths: ½″ ID x 1″ OD up to 7¾″ ID x 10⅜″ OD)
- **Plate Stock**
  (½″ wide x 2½″ long up to 12″ wide x 24″ long. Thickness ⅛″ to 1″)
- **Circular Plates (Discs)**
  (1″ ID x 3″ OD up to 4″ ID x 6″ OD. Solid up to 18″ OD. Thickness ¼″ to ⅜″)
- **Strip Stock**
  (6″ wide x 36″ long; 1/32″ or 1/16″ thick)



OILITE IS EASY TO MACHINE. Boring, turning, drilling and all other conventional machining operations can be done. High surface speeds, fine feeds and sharp tools preserve OILITE'S open pore structure and self-lubricating properties.

Self-lubricating, oil cushion bronze bearings (20% oil by volume) can be quickly machined for new design developments, prototypes, and emergency machinery repairs—when you have a supply of OILITE Bronze bearing material on hand. Available in a wide range of shapes and sizes from stock. Contact your Amplex OILITE representative for details.

NEW STOCK LIST (S-60). Includes all standard sizes of OILITE Bronze solid and cored bar stock, plates, discs and strips; Super-Oilite solid and cored bar stock. Also 1081 standard sizes of OILITE Bronze self-lubricating bearings. All available from stock. *Send for your free copy.*

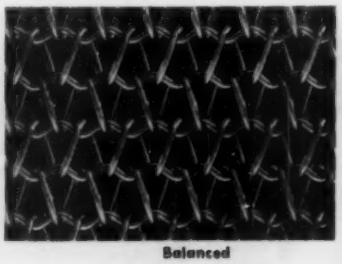
AMPLEX

DIVISION CHRYSLER CORP.

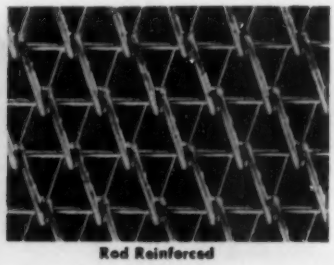
DETROIT 31, MICHIGAN

A CHRYSLER OILITE PRODUCT

IN DESIGNING FOR CONTINUOUS PROCESSING OF PARTS THROUGH HOT, COLD, WET, DRY OR CORROSIVE PROCESSES . . . SPECIFY



Balanced



Rod Reinforced

Two of the weaves most commonly used in processing operations

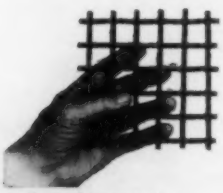
Cambridge METAL-MESH CONVEYOR BELTS

Cambridge Belts are available in nine basic weaves with mesh sizes ranging from ½″ to 2″, any size or length, including a Collapsible Belt for easy cleaning, Teflon-coated Belts, etc.

Continuously moving Cambridge Belts speed production, eliminate manual handling and batch processing. Open mesh allows free circulation of air or liquids, fast drainage of solutions. All metal construction resists sub-zero to 2100° F. temperatures, corrosive or abrasive conditions. Elimination of seams, lacers or fasteners gives longer service life, less maintenance. All types of side or surface attachments available.

Currently, Cambridge Belts are used in such diversified operations as heat treating, annealing, baking, freezing, drying, brazing, oiling, quenching and hundreds of others.

IN DESIGNING FOR SCREENING, STRAINING, SIZING, FILTERING, CLEANING OR DEHYDRATION OPERATIONS . . . SPECIFY



From the coarsest . . .

to the finest mesh

Available in nine basic weaves, woven from any metal or alloy, including titanium, platinum, silver, etc.

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Quality is one of the most important characteristics of Cambridge wire cloth. Accurate mesh count and mesh size are assured by constant checking and inspection, from raw material stage through final packing for shipment. To assure complete satisfaction, a Cambridge Field Engineer follows up to make sure our product is giving the best possible service.

WIRE CLOTH can usually be shipped immediately from the thousands of different sizes and meshes of the most frequently used weaves kept on hand in our warehouse. If what you want is not on hand, we'll schedule our looms to get it to you *as soon as possible.*

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See your Cambridge Field Engineer for full information on Cambridge Metal-Mesh Conveyor Belts or Cambridge Industrial Wire Cloth. He's listed in the yellow pages of your telephone directory under "Belting, Mechanical" and "Wire Cloth." Or, write for your copies of our TECHNICAL MANUALS on Conveyor Belts and Wire Cloth.

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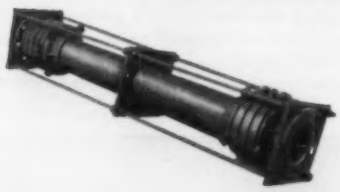
...masters of precision-formed thin metals!

FLEXONICS METAL HOSE AND FITTINGS

Annular and helical corrugated; packed and non-packed interlocked hose—to control the effects of pressure, temperature, and motion in conveying any medium. Made in all metals, in the broadest range of types and sizes—standard up to 24" I.D. Wide range of hose and fittings immediately available from local distributor stocks. Special requirements are met on request.



FLEXONICS EXPANSION JOINTS

Expertly engineered to your needs . . . hydraulically formed . . . metallurgically quality-controlled by exclusive techniques, for maximum cyclic life. Also Flexonics Expansion Compensators—inch for inch the lowest-cost way to absorb thermal growth in pipe and tubing 3" and smaller.

FLEXONICS BELLOWS

For measurement of pressure and temperature . . . for sealing . . . for operation of mechanisms. Available in all metals—including Flexonics-pioneered stainless steel—in the broadest range of sizes.

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Thin-wall stainless steel tubing and precision-fabricated ducting assemblies and configurations; flexible ducting sections; gimbal joints; pin joints; free-flexing joints—all designed specifically for the needs of the aero/space industries and formed by exclusive Flexonics methods to do more with less weight and less space. Also, complete line of aeronautical metal hose and fittings.

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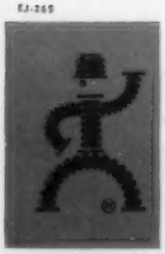

Flexonics
corporation

In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ont.

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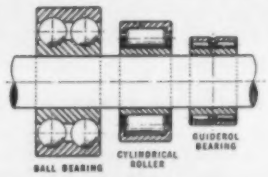
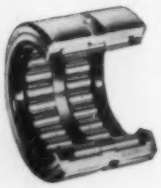
McGILL®

GUIDEROL® bearings offer higher load

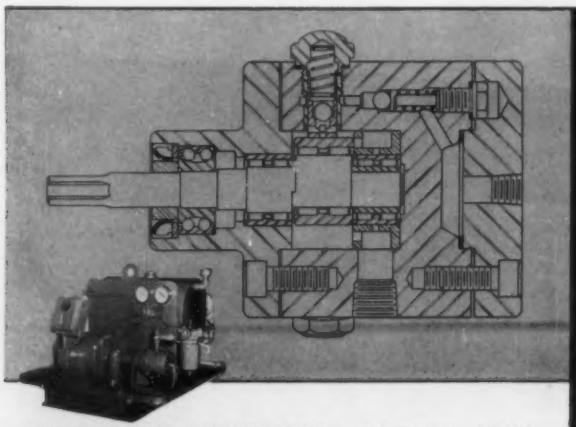
GUIDEROL bearings pack more high capacity performance into smaller radial space. Their construction features the extra capacity of a full complement needle bearing and effective roller control. Center guided rollers limit skewing and prevent binding under adverse conditions in either horizontal or vertical mountings. For a common 1″ shaft, the GUIDEROL bearing has an O.D. of only 1½″ with a capacity of 6310 lbs. Compared to a cylindrical type roller bearing, the GUIDEROL bearing requires ⅜″ less housing space and offers 23% more capacity. A ball bearing for the same shaft uses almost an inch larger O.D. to carry 1500 lbs. less radial load. Space-saving GUIDEROL bearings simplify design and cut housing space requirements. Available with or without inner rings in shaft sizes from ⅝″ to 9¼″ with capacities ranging from 2880 lbs. to 128,670 lbs. (at 100 RPM).



Sealed Guiderol Bearings Protect Performance Life and Cut Maintenance



Pre-lubricated and sealed GUIDEROL bearings lock lubrication in and seal contamination out. Interchangeable dimensionally with GUIDEROL GR Series bearings, they cut maintenance in two ways. Bearings last longer and frequent re-lubrication is not required. 5 different seal combinations are available to fit specific mounting requirements.

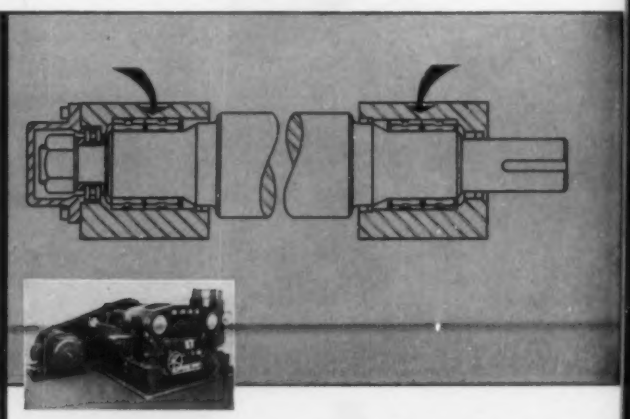


SIMPLEX ENGINEERING USES GUIDEROL BEARINGS IN HIGH PRESSURE HYDRAULIC PUMPS

The SECO "LA" Series pumps, shown in cross section above, are fixed displacement seven piston radial pumps, utilizing unique patented principles which enable them to generate pressures as high as 10,000 PSI without loss of mechanical efficiency. SECO pumps are manufactured by the SIMPLEX ENGINEERING COMPANY, a subsidiary of RACINE HYDRAULICS & MACHINERY, INC.

MCGILL GUIDEROL MT Series bearings are used as shaft support bearings, and center eccentric floating bearings in these and other series Simplex pumps.

SIMPLEX reports unusual success with heavier loads and most satisfactory bearing life through ten years of use of MCGILL bearings. They have helped to produce the strikingly long life for which these pumps have become famous.



KANE AND ROACH LEVELER SHAFTS ROLL ON GUIDEROL BEARINGS

Kane and Roach depends on 26 matched pairs of GUIDEROL bearings to carry the leveling and flat straightening loads resulting from rolling alloy steels of 80,000 PSI yield. They are used on K & R No. 7 Levelers as roll neck bearings on the 11 power driven main leveler shafts and on the pair of adjustable pinch roll shafts that guide entry of alloy steel bars up to 1″ thick by 8″ wide.

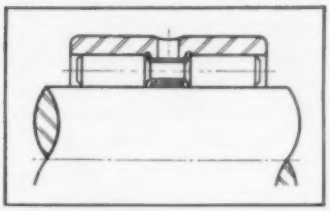
Shown are the matched GUIDEROL bearings in their roll neck mountings. Driven through universal joints at 38 to 114 RPM, the power rollers, supported at each end by pressure lubricated GUIDEROL bearings, provide production speeds of 70 to 210 feet per minute.

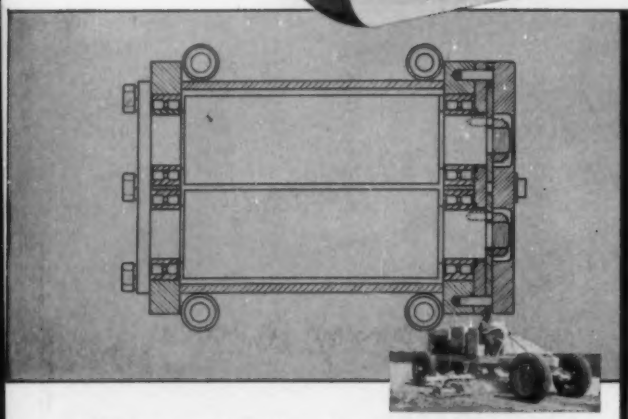
Kane and Roach uses GUIDEROL bearings in many applications with complete assurance of extra capacity and dependable performance with minimum maintenance.

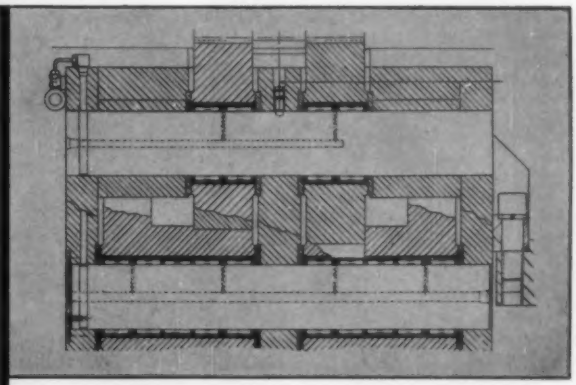
WRITE TODAY FOR FREE McGILL BEARING CATALOG No. 52-A for complete data on McGILL GUIDEROL, CAMROL, MULTIROL and CAGEROL BEARINGS.

capacity in smaller radial space

GUIDEROL BEARING
Cutaway to show center guided roller principle







GUIDEROL BEARINGS WITHSTAND VIBRATION IN LIMA ROADPACKER APPLICATION

GUIDEROL bearings support the off-balance rotors which produce vertical vibration in the six vibrator assemblies of each LIMA ROADPACKER machine. The drawing shows the position of 4 rotor support bearings. A gear motor drives the rotors which are one-half filled with lead to produce vibration for road compacting.

The user states that GUIDEROL bearings were selected because of high capacity in limited diameter and their ability to withstand extensive off-balance vibration. Possible end floating of the separable bearing fits the design very nicely. Performance is considered most satisfactory as the bearings easily resist the eccentric loading.

GIDDINGS & LEWIS SKIN MILLING MACHINE APPLICATION REQUIRES GUIDEROL RIGIDITY — MINIMUM DEFLECTION

GUIDEROL BEARINGS, IN MATCHED SETS are used to mount the reduction gearing in the table drive gear box of each NUMERCOID tape controlled skin milling machine. The drawing shows a partial section of the table drive. GIDDINGS & LEWIS MACHINE TOOL CO. cites excellent performance of the GUIDEROL bearings. Guided rollers in this bearing have eliminated the problem of having the roller bind on the shaft if slight misalignment is present. The drive assembly mechanism reduces back lash by using a pre-loaded gear arrangement and matched bearings. The bearings are flooded with oil through the center of the shaft. Speeds are 1/30 to 460 RPM.

engineered electrical products

McGILL®

precision needle roller bearings

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Div.,
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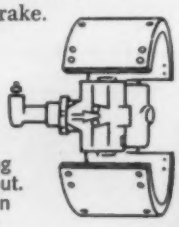
CIRCLE 301 ON READER SERVICE CARD 301

ACTUAL TESTS PROVE:

NEW STOPMASTER BRAKE IS the most advanced brake design in 30 years!

Over three years of thorough and demanding road tests have proven the superiority of the new Rockwell-Standard Stopmaster Brake. Of its many new improvements the Stopmaster incorporates these major advantages to meet the modern trucking industry's demand for a more efficient, more dependable brake.

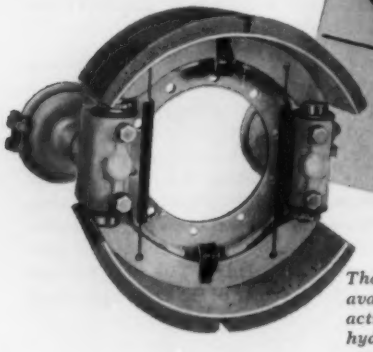


New Stopmaster actuation principal results in higher braking efficiency with less input. In dual actuation design both shoes do an equal amount of work over the entire lining surface. This balanced shoe action assures more dependable service; faster, surer stops; less maintenance.

New Stopmaster 15" diameter permits increased air circulation between brake drum and wheel rim. This results in cooler operating temperatures . . . less heat fade, longer lining life, longer drum life. Smaller diameter means less weight.

AVERAGE RESULTS OF NUMEROUS HIGHWAY VEHICLE TESTS PROVE:

- **35% lighter weight..** more payload capacity!
- **38% less heat fade..** safer, more continuous operation!
- **57% less air volume required..** permits smaller air reservoir tanks!
- **56% longer lining life..** lower operating cost, less maintenance!
- **56% longer drum life..** more dependability, less downtime!
- **66% less adjustment required..** greater safety, reduced maintenance!
- **37% less service parts** smaller inventories, less expensive!



The Stopmaster 15" Brake is available with either air or hydraulic actuation . . . also up to 30" diameter, with hydraulic actuation for heavy-duty, off-highway vehicles.

Another Product of...

ROCKWELL-STANDARD CORPORATION

Brake Division, Ashtabula, Ohio

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However you make it—
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To seal it—
POSITIVELY!
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A DIVISION OF Parker Hannifin CORPORATION
*Formerly Franklin C. Wolfe Co. and Parker Rubber Division

New Chassis-Trak Utility Slides Support 15 Times Their Own Weight

Three Models—TILT, TILT-DETENT, and NON-TILT

With the introduction of the C-230 Utility Slide, Chassis-Trak can now offer a complete line of electronic cabinet slides in a capacity range from 50 to 275 lbs. The new Utility Slide can be used in any standard rack and in any type of mobile or stationary installation where the chassis load does not exceed 100 lbs.

Chassis-Trak's famous "pencil thin" design is an outstanding advantage of the new C-230. A pair of these fully-extendable slides take up only .620" of usable chassis space—far less than any other slides of equal capacity.

Made of hard, cold-rolled steel, each slide is cadmium plated and then coated with Poxylube 75. This is a bonded film of molybdenum disulfide which provides permanent dry lubrication and protects the metal against solvents, acids and corrosion.

Chassis-Trak C-230 slides are available in seven lengths—12" to 24"—and in a choice of tilt, tilt-detent or non-tilt models. The detent model locks in three positions—90° up, horizontal, and 90° down—for convenience in servicing tube and circuitry sections.

For complete details and specifications on the new C-230 Utility Slide, request Engineering Data Sheet 1600.

for further information, contact

525 South Webster Avenue, Indianapolis, Indiana

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√ For Laboratory Work.
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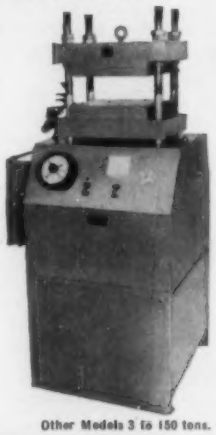
- Accurate heat and pressure controls.



Other Models 3 to 150 tons.

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1582 Morris St.
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Now available in a *new edition*... with *new figures.*

This popular booklet points up the important sales problem of personnel turnover in industry. Out of every 1,000 key men (over a 12-month period) 343 new faces appear . . . 65 change titles . . . 157 shift . . . and 435 stay put. These figures are based on average mailing address changes on a list of over a million paid subscribers to McGraw-Hill magazines.

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catalogs and bulletins.....continued

(F-64) Desk-top Computer—Brochure, 9 pp. Solutions by 93 lb analog computer presented on xy plotter, strip chart or oscillograph. Electronic Associates, Inc, Long Branch Ave, Long Branch, NJ.

(F-65) Dry Film Lubricant—Bulletin, 18 pp. Explains design considerations when using this lubricant. EverLube Corp, 6940 Farmdale, N Hollywood, Cal.

(F-66) Instrument Ball Bearings—Catalog, 44 pp. Provides sections on manufacture, engineering data, dimensions and tolerances, selection. The Fafnir Bearing Co, Booth St, New Britain, Conn.

(F-67) Ball Bearings—Catalog, 170 pp. Presents dimensions, bearing life tables and load ratings for many types of single and double row ball bearings. Includes 40 page section of general engineering information. The Federal Bearings Co, Inc, Poughkeepsie, NY.

(F-68) Air Suspensions—Bulletin, 32 pp. Contains graphs, tables and discussions for use as design guide. Can be used with vehicle suspension or vibration and shock isolation of machinery. Firestone Industrial Products Co, Firestone Blvd at 17 St, Noblesville, Ind.

(F-69) Lubricants—Bulletin, 32 pp. Lists properties of fluid and grease lubricants. Makes recommendations for industrial machinery. Lubriplate Div, Fiske Bros Refining Co, 129 Lockwood St, Newark, NJ.

(F-70) Metallic Bellows and Bellows Assemblies—Catalog, 8 pp. Presents design and application information for single and multiple ply bellows of stainless steel, monel, hastelloy, brass and bronze. Includes a variety of end fittings. Flexonics Corp, 1315 S Third Ave, Maywood, Ill.

(F-71) Fittings for Plastic Tubing—Brochure, 4 pp. Describes how fittings work. Tells how to order. Flodar Corp, 16911 St Clair Ave, Cleveland 10.

(F-72) Ball Bearings—Catalog, 22 pp. Five groups of semi-precision bearings range from both races stamped to both races machined. Some are installed in subassemblies. Freeway Washer & Stamping Co, Box 1756, Cleveland.

(F-73) Packings—Catalog, 46 pp. Provides tables of dimensions, description of properties for many types of rubber and leather o-rings, v-packings, cup packings and others. Albert Trostel Packings, Ltd, Lake Geneva, Wisc.

(F-74) Wheels—Brochure, 15 pp. Dimensions and load ratings given for tire, disc, bearing wheel units. Includes high and low speed types. Geneva Metal Wheel Co, Geneva, Ohio.

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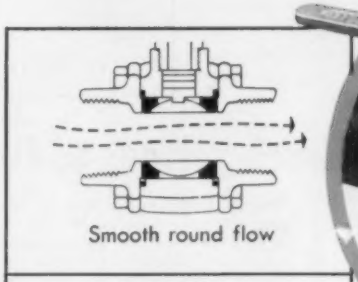

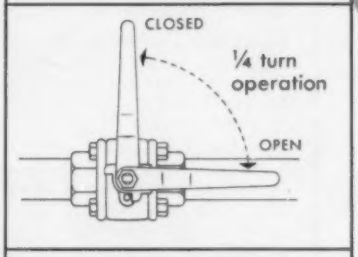

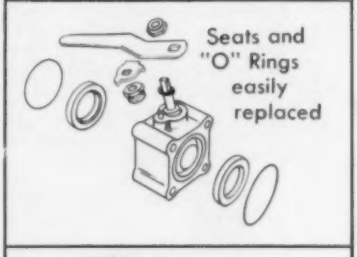

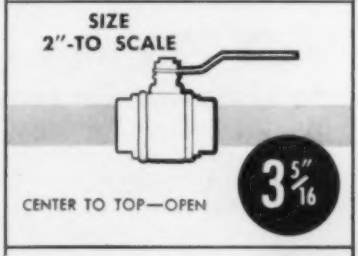

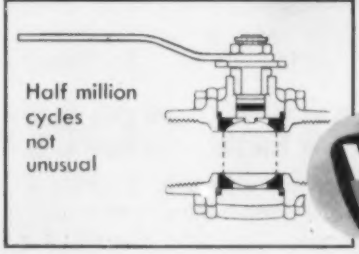

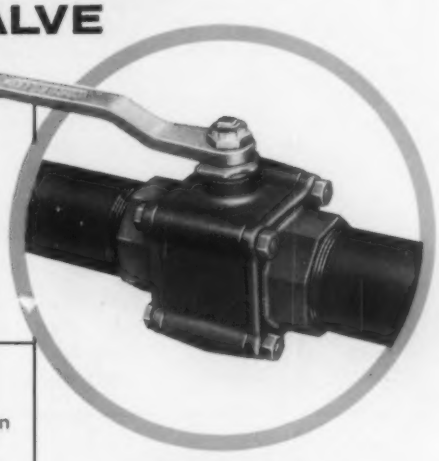

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FLOW CHARACTERISTICS
Smooth Round Two-Way Flow through the valve — minimum pressure loss and turbulence.

COMPARE
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¼ Turn Operation. Easily adaptable to remote control. Also, visual indication of open or closed position.

COMPARE
MAINTENANCE CHARACTERISTICS
In-Line maintenance — simply remove four bolts and replace seats and seals in the center section, without disturbing the line. Serves as both valve and union.

COMPARE
SIZE
Compactness for ease of installation in confined areas. Approximately ⅓ the height of a comparable gate valve.

COMPARE
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Half Million cycles not unusual with Econ-O-Miser. No scratching of metal-to-metal surfaces — excellent for slurries and abrasive media.

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CIRCLE 305 ON READER SERVICE CARD 305

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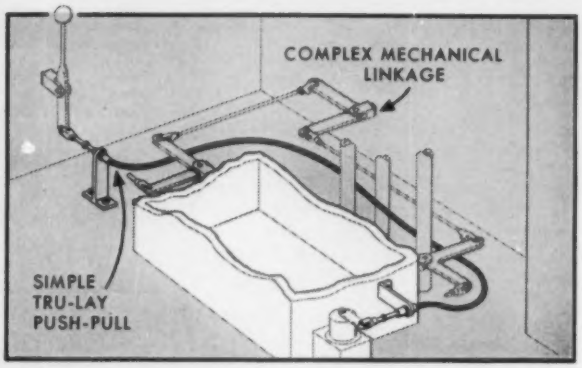
• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000

Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

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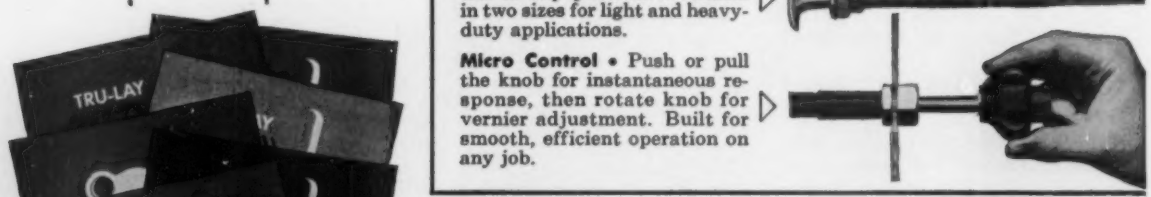
Position Lock • A slight turn of the T-type handle locks the control in any position. Available in two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment. Built for smooth, efficient operation on any job.



PUSH-PULL DATA FILE shows how to simplify, improve design

PUSH-PULL CONTROLS are solid as a rod and flexible as a wire rope. They're factory-lubricated for life, unaffected by temperature extremes, and can be adapted to practically any application. For complete details on how you can use them, write for the PUSH-PULL DATA FILE. It contains 7 engineering Bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages. Our engineers will be glad to help you make TRU-LAY PUSH-PULL CONTROLS a part of your product.

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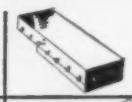
Gilman PRECISION SLIDE ASSEMBLIES

...available FROM STOCK in 132 standard types and sizes

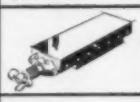
LIGHT DUTY BASIC TYPE

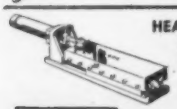

HEAVY DUTY BASIC TYPE

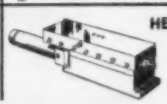
LIGHT DUTY TYPE WITH RETURN SPRING

HEAVY DUTY MICROMETER STOP TYPE

LIGHT DUTY LEAD SCREW TYPE


HEAVY DUTY LEAD SCREW TYPE


HEAVY DUTY CYLINDER POWERED (in-line mount)


HEAVY DUTY CYLINDER POWERED (lower mount)

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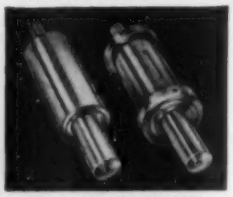
MECHANICAL PARTS AND DESIGNS

Gilman CARTRIDGE-TYPE SPINDLE ASSEMBLIES



(Left) plain type. (Right) with longitudinal positioning nuts. Both are shown with BLANK SPINDLE END for machining by user.

... available from stock in 28 standard types and sizes

AVAILABLE in plain cylindrical type or with longitudinal positioning nuts. Five types of spindle noses are offered. Range of cartridge diameters from 1.250" to 2.750".

Design Advantages

- Steel spindles are precision machined and ground, with close tolerances maintained throughout.
- Matched, double-row ball bearings at tool end of spindle ... single-row ball bearings at the driven end.
- Positioning nuts are graduated in increments of spindle adjustment of 0.001".
- Spindle assemblies can be mounted in a bored hole or in Gilman precision mounting brackets.

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CIRCLE 639 ON READER SERVICE CARD

"Dyflon"®

Self-Aligning and Self-Lubricating

SPHERICAL BEARINGS

Combine "Monoball"® Engineering Advantages with Life-Time Lubrication

Design engineers in many industries are specifying new "DYFLON"® SELF-ALIGNING and SELF-LUBRICATING SPHERICAL BEARINGS for these 5 major reasons:

1. **LOWER COEFFICIENT OF FRICTION** ... ideal where lubrication is impossible or undesirable.
2. **WITHSTAND EXTREME VIBRATION** ... perfect performance under shock load conditions.
3. **WILL NOT "COLD-FLOW"** ... even under extreme load conditions.
4. **IMPERVIOUS TO KNOWN CHEMICAL SOLVENTS** ... eliminates corrosion problems.
5. **FAIL-SAFE** ... due to "Monoball"® design.

Request Engineering manual No. 551.

In addition, due to their two-piece "MONOBALL"® design and plastic alloy insert, "DYFLON"® bearings have a long cycle life. Alignment and installation problems are minimized. Oil-free for life means lowest possible maintenance costs.

Available in a variety of plain or rod end types. Bore sizes to 3.000". Materials include stainless steel, plastic alloys and chrome alloy steels. Ultimate static loads to 500,000 lbs.

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catalogs and bulletins.....continued

(F-75) Accelerometers—Catalog, 18 pp. Provides dimensions, specifications, construction details of accelerometers for aircraft and missiles. Genisco, Inc, 2233 Federal Ave, Los Angeles 64.

(F-76) Rate of Turn Tables—Data Sheets, 6 pp. Describes test equipment for calibrating and evaluating rate gyroscopes. Genisco, Inc, 2233 Federal Ave, Los Angeles 64.

(F-77) Lubrication—Catalog, 28 pp. Furnishes dimensions and illustrations of oilers, grease cups, sight gages, shaft seals and others. Gits Bros Mfg Co, 1846 S Kilbourn Ave, Chicago 23.

(F-78) Wheels and Casters—Catalog, 16 pp. Describes casters with load ratings up to 600 lbs. Wheels are of rubber, solid steel, phenolic. Gleason Corp, 251 N 12 St, Milwaukee 3.

(F-79) Casters and Wheels—Four bulletins, 8 pp. Provides dimensions, tire styles, bearing types for industrial and juvenile applications. Goddeyne Wheel Products, 1300 N McLellan St, Bay City, Mich.

(F-80) Electronic Instruments—Bulletins, 13 pp. Presents capabilities and electrical characteristics of transfer function computer and airborne telemetry gear. Gulton Industries, Inc, Ortholog Div, Box 37, Princeton Junction, NJ.

(F-81) Bushings—Bulletin, 7 pp. Provides description, sizes, dimensions, mounting holes dimensions, prices of strain relief, snap and junction terminal bushings. Heyman Mfg Co, Kenilworth, NJ.

(F-82) Spherical Roller Bearings—Brochure, 16 pp. Tables give dimensions, load and life ratings of double-row, self-aligning bearings. Shaft bores go up to almost 20 in. Hoover Ball & Bearing Co, 5400 S State Rd, Ann Arbor, Mich.

(F-83) Ball Bearing—Bulletin, 12 pp. Provides design information for bearings up to 7½ in. OD and 7200 rpm. Hoover Ball & Bearing Co, 5400 S State Rd, Ann Arbor, Mich.

(F-84) Lubricators—Catalog, 40 pp. Describes force feed mechanical lubricators for machinery and compressors. Includes various charts and diagrams for pairing units with pressure, lubricant, capacity. Manzel, unit of Houdaille Industries, Inc, 315 Babcock St, Buffalo, NY.

(F-85) Desk Computer—Bulletin, 8 pp. Describes research and engineering computer with solid state circuits, magnetic core memory. Input is by punched tape. Output is in decimal form. International Business Machines Corp, 112 E Post Rd, White Plains, NY.

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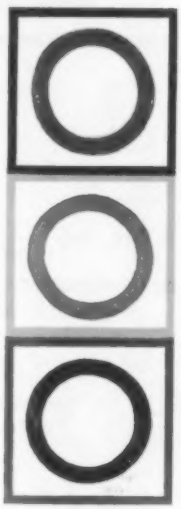
is a better buy than lost time on the assembly line!

BEFORE you go into production is the time to let a Precision Sales Engineer analyze your problems, recommend solutions. As a recognized "O" Ring specialist, his knowledge and skill can help you improve product operation, simplify design, reduce assembly costs and eliminate early product failure. He'll help you obtain the right product design, then recommend the right "O" ring for the job. Precision "O" Rings are rigidly inspected, true to size and meet all military and commercial specifications.
Be safe with Precision. Write, phone, or wire for the services of a Precision Engineer today.



BE SAFE WITH PRECISION

Precision Rubber Products Corporation • "O" Ring and Dyna-seal Specialists

Dept. 6, Oakridge Drive, Dayton 17, Ohio Canadian plant at: Ste. Thérèse de Blainville, Québec

IF A *MINIATURE* OR *INSTRUMENT* BEARING IS NEEDED . . .

NEW HAMPSHIRE

. . . IS THE *SOURCE!*

To meet the exacting requirements of your applications, New Hampshire maintains a full line of miniature and instrument bearings for research and development, prototypes and replacements at all regional offices. (Production quantities are shipped direct from our main plant.) NHBB sales engineers are always on call to discuss your particular needs and make specific recommendations.

Retainer Bearing Plain

Retainer Bearing Flanged

Retainer Bearing Shielded

Retainer Bearing Flanged & Shielded

RETAINER BEARINGS

This is one of the most frequently specified types for instrument applications. Available with newly designed crown retainers. This design permits even ball spacing, low torque, and most consistent performance. *Over 370 standard types and sizes are listed in our Design Manual.*

SIZES

(Available in a wide selection of combinations within the following ranges)

	BORE	O.D.	WIDTH
Min.	.0400	.1250	.0469
Max.	.3125	.6250	.1960

EXTENDED INNER RINGS . . . available on all above types

FULL BEARINGS

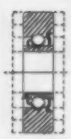
Full bearing (Available plain or flanged)

Specified for applications requiring maximum radial load capacity. Not suited to low torque requirements. *Over 21 standard types and sizes.*

SIZES ➡

	BORE	O.D.	WIDTH
Min.	.0250	.1000	.0312
Max.	.3125	.5000	.1562

UP and WAFER BEARINGS


A wafer bearing compared with standard equivalent

Expressly designed for use in synchros, servos, small motors, potentiometers, and gear trains. Widths are significantly narrower than standard to allow more room for rotors and stators. *Available in 16 types and sizes.*

SIZES:	BORE	O.D.	WIDTH
Min.	.0550	.1875	.0937
Max.	.1875	.4375	.1094

QUALITY PERFORMANCE . . .

is in direct relation to quality of production. *All New Hampshire bearings* are made to ABEC-7 tolerances or better. The result is *improved running qualities* for all users . . . at no extra cost! In addition, rigid quality control during manufacture and continuing research enables New Hampshire to maintain leadership in our field . . . to supply you with the finest bearings for your needs at the lowest cost.

IMMEDIATE DELIVERIES FROM STOCK . . .

(For research & development, prototypes, and replacements) are made from our three regional offices as well as the main plant. Bearing specialists are on hand to help you plan and specify. Call your nearest office collect for fast service.

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HUnter 2-8633 TWX: 1421U

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HOLLYWOOD 28, CALIFORNIA
HOllywood 4-0208 TWX: LA 933U

(main plant)
PETERBOROUGH, NEW HAMPSHIRE
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NEW DESIGN MANUAL

Newly revised and expanded, this authoritative publication is a guide to designing around, specifying and purchasing of miniature and instrument ball bearings. Comprehensive general information, catalog data, and engineering bulletins are included in the 100-plus pages. A personally registered copy is available to qualified engineers, draftsmen, and purchasing departments.

For your free Design and Purchasing Manual, write or call any New Hampshire Office.

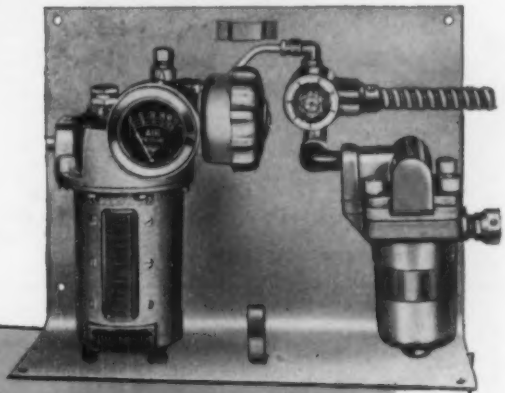
NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

How to choose a

LUBRICATION SYSTEM

that provides constant, uniform lubrication

at savings of up to 90%



use this handy check list:

Will your lubrication system be fully automatic? Oil-Mist starts and stops at the touch of your machine switch.

Will the system that you choose cut oil consumption by 90%? With the Alemite Oil-Mist System you can get better bearing lubrication with only 1/10th as much oil as required by other methods.

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Lubricates any bearing on any machine in One Of Three Ways:

Oil-Mist for high speed anti-friction type of bearings.

Oil Spray for low speed anti-friction and open and enclosed gears and chains.

Condensed Oil for plain bearings, slides, ways, vees, cams, and rollers.

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STEWART-WARNER CORPORATION

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☐ Please have your Alemite Lubrication Representative arrange a no-obligation demonstration.

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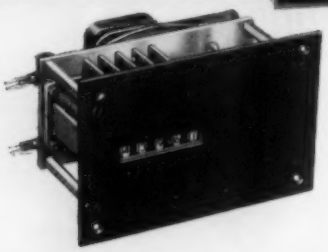
CIRCLE 311 ON READER SERVICE CARD 311

Veeder-Root COUNTER READOUT Bulletin

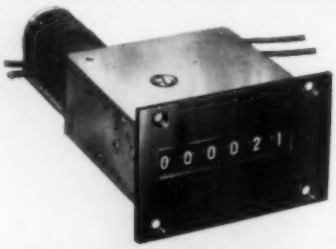


Data Readout Counters

Each wheel has ten-position switching mechanism for transmitting counter readings electrically. Actuated mechanically or electrically.

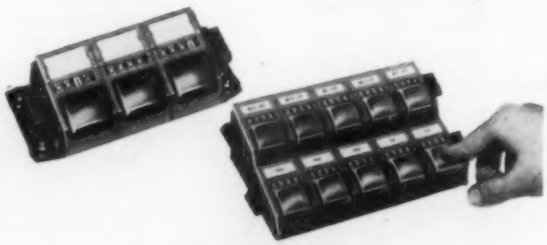
General-Purpose Counters

A complete square case line for light duty counting where small size is required. Available as direct drive, revolution, ratchet, rotary ratchet and geared counter.



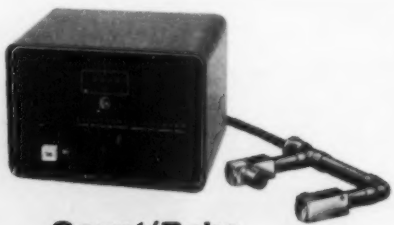
Magnetic Counters

For remote indication. Actuated electrically by variety of switches or photocells. High speed, quick reset model features 3000 cpm, small panel area.



Vary-Tally

Multiple unit reset counter for more accurate tallying. Ideal for quality control, production control, piece work, and analysis work. Available in strips and tiers.



Count/Paks

Complete packages for high speed, non-contact counting. Pulse stretching circuit for counting small objects. Photohead designed for specific applications.

Miniature Precision Counters

Complete line of specialized counters and readout devices for military, aircraft and missile instrumentation. Precision gearing and complete "systems" available.

Electronic Countrols

Predetermining Counters provide automatic control of machine operations, with single stop motion or series of sequential stop motions. Count electrical impulses, speed to 5000 counts per second.

Send for catalog information and data sheets on the complete line of Veeder-Root Counters.

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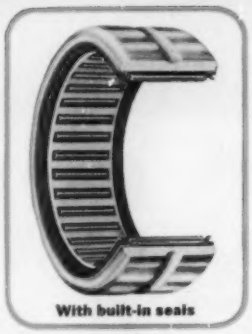
ORANGE ROLLER BEARINGS

Without seals


With built-in seals

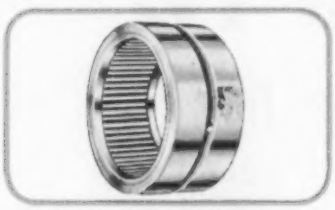
Wide choice of Types and Sizes enables you to

MATCH THE BEARING TO THE JOB

for maximum load capacity — speeds — life expectancy — and economy

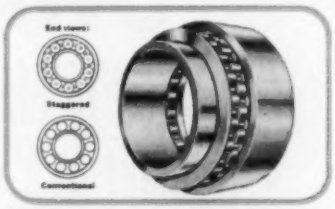
ORANGE *Cage Type* NEEDLE BEARINGS

Precision needle rollers are permanently aligned in pockets of anti-friction cage—resist skewing while running in vertical, tilted or horizontal position. Successful on overhung mountings; less affected by misaligned mountings or shaft deflections. Sizes, without seals, ½″ to 8″ shaft dia.; with built-in seals, ½″ to 2″ shaft dia.



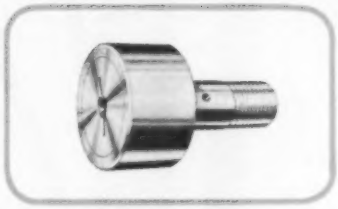
ORANGE ROLLER BUSHINGS

Full type precision needle bearings provide maximum load capacity in small radial space. Close internal running clearances minimize possibility of misaligned rollers. Standard sizes ½″ to 8″ shaft dia.



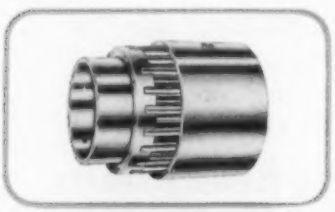
ORANGE STAGGERED ROLLER BEARINGS

Exceptionally high load capacity and even running are gained by use of many short rollers in staggered arrangement, instead of fewer long rollers. All standard, interchangeable sizes in the 200 and 300 series.



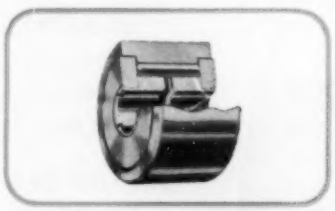
ORANGE CAM FOLLOWERS

Provide high load capacity and shock resistance. Standard sizes from ½″ to 4″ O. D. with either standard or heavy-duty studs. Chrome, Cadmium or Black Oxide finishes available; also seals where required.



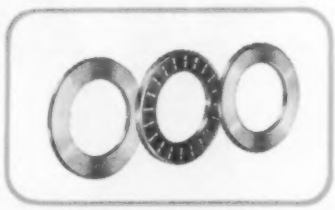
ORANGE JOURNAL ROLLER BEARINGS

Provide high load capacity where radial space is limited. Available as complete bearings or as component parts in inch sizes, in multiple lengths, ⅝″ to 5″ shaft dia.



ORANGE CAM YOKE ROLLERS

For yoke mountings involving follower action, and for machine elements requiring guide or support rollers. Standard sizes from ¾″ to 4″ O. D. Chrome, Cadmium or Black Oxide finishes available; also seals where required.



ORANGE THRUST ROLLER BEARINGS

Cylindrical roller type thrust bearings provide high capacity and durable service. Available in light series ⅞″ to 3½″ bore; heavy series from 2″ to 16″ bore. Special types and sizes to order.

Engineering representatives and distributors in all industrial areas

ORANGE ROLLER BEARING CO., Inc.
558 Main Street, Orange, N. J.

Send for 48-page Engineering Reference Manual showing dimensions, capacities, installation data on all Orange Roller Bearings.

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Simplify design...position parts to best advantage...eliminate alignment problems with S.S.White Flexible Shafts for

REMOTE CONTROL...POWER DRIVE...COUPLING...

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S.S.WHITE STANDARD FLEXIBLE SHAFTS ...are complete, ready-to-attach, always in stock. Save you engineering time...give you "off-the-shelf" savings. Four standard sizes.

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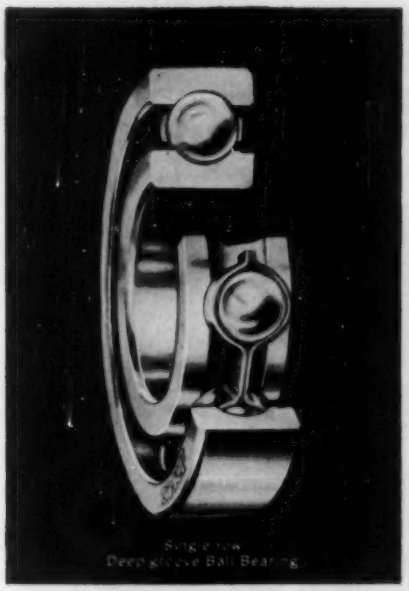


Can a standard bearing offer you "more bearing" for your money?

It can if it's made by SKF—because all SKF bearings, both ball and roller, offer special qualities at "production" bearing prices.

Take the single-row deep-groove ball bearing featured here, as an example. SKF designs and builds this type to sustain heavy radial load and thrust load in either direction. Furthermore, it is engineered to run smoothly and quietly at normal speeds with grease lubrication—and at high speeds with oil.

Yet this is a standard SKF ball bearing, mass-produced by automated production equipment at our plant at Altoona, Pa. You can quickly get this bearing in over 100 sizes, ranging from 5/8" to 15.748" O.D., and in a variety of seal, shield and snap-ring combinations.

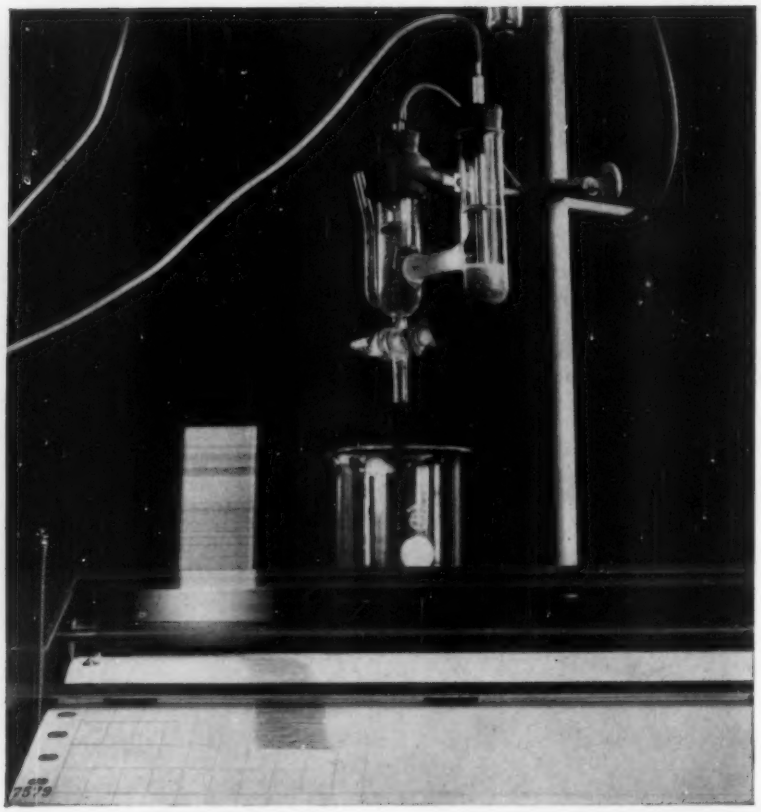
But why not find out what SKF offers in bearing quality, availability and economy? Just call the SKF branch office nearest you.

6001

Spherical, Cylindrical, Ball, Tyson Tapered and RELD Miniature Bearings
EVERY TYPE—EVERY USE
SKF
INDUSTRIES INC. PHILADELPHIA 32, PA.

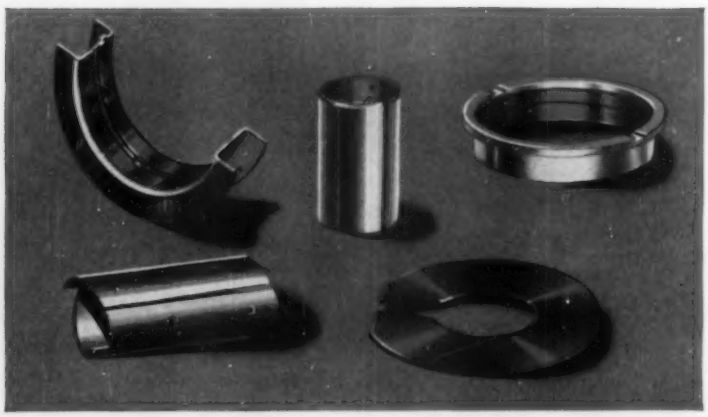
MECHANICAL PARTS AND DESIGN ANALYSIS

ANALYTIC "BLOODHOUND" SNIFFS OUT SECRETS OF BEARING CORROSION



WE USE THIS HYPERSENSITIVE DEVICE TO TRACK DOWN ENGINE BEARING CORROSION TO ITS SOURCE. This instrument needs only a minute fragment of metal for accurate analysis. Consequently, engine bearing corrosion can be traced from its beginning through complete destruction of the bearing surface. Because test variables are minimized, Federal-Mogul engineers can accurately relate degree of corrosion to specific engine operating conditions. This analytical tool is in continual use in our laboratory, assisting research on many different projects. Prevention of corrosion and development of new bearing alloys are high on the list!

SUCCESSFUL BEARING PERFORMANCE depends on selecting the proper alloy for the operating conditions to be met. Federal-Mogul engineers have had years of experience with bearings and applications of all kinds . . . and this wealth of knowledge is available to bearings users. This is one reason why F-M sleeve bearings, precision thrust washers, formed bushings, and low-cost spacers are chosen for use in virtually everything from baby buggies to heavy industrial cranes.



There's much valuable data in our Design Guides on sleeve bearings, thrust washers and bushings; and in our brochure on spacers. For your copies, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11043 Shoemaker, Detroit 13, Michigan.

FEDERAL-MOGUL

sleeve bearings
bushings-spacers
thrust washers

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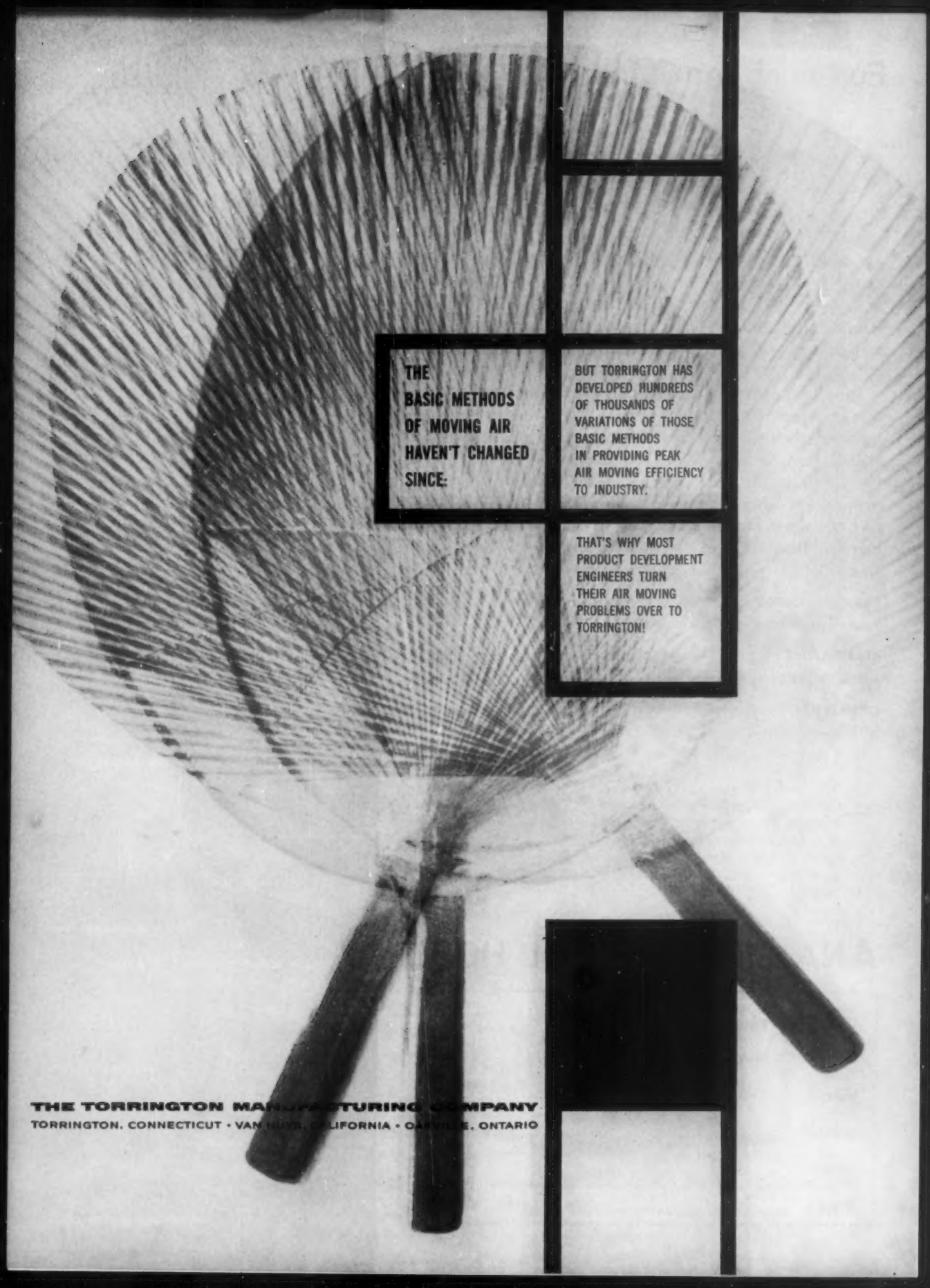
CIRCLE 317 ON READER SERVICE CARD→


THE
BASIC METHODS
OF MOVING AIR
HAVEN'T CHANGED
SINCE:
BUT TORRINGTON HAS
DEVELOPED HUNDREDS
OF THOUSANDS OF
VARIATIONS OF THOSE
BASIC METHODS
IN PROVIDING PEAK
AIR MOVING EFFICIENCY
TO INDUSTRY.
THAT'S WHY MOST
PRODUCT DEVELOPMENT
ENGINEERS TURN
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PROBLEMS OVER TO
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ANACONDA
A-X TUBING

Anaconda A-X tubing is a flexible metal connector with annular corrugations designed to handle the types of movement shown at the right while conveying liquids or gases. It is available in stainless steel and other alloys and is generally sold complete with fittings (right, below). Nominal tubing I.D.'s: 5", 6", 8", 10", 12", 14".

Most axial motion applications involve motion in one direction in respect to the installed position. This may result in compression or extension of the tubing. In a few applications an assembly may be subjected to both extension and compression in relation to the installed length – such cases occur when temperature varies both above and below installation temperature. In order to give the best service for each type of application there are three different corrugation standards for each tubing size:

PRE-COMPRESSED. Designed for extension movement. Will allow a small amount of compression.

STANDARD. Designed for compression movement. Will allow a small amount of extension.

OPEN PITCH. For elbow forming, ducting, or misalignment where little movement is required.

60123

Bulletin A-X 97 gives complete details. Call your Anaconda Metal Hose representative for a copy—or for the services of an Anaconda specialist to help you in the design of a special connector to meet your needs. Or send in coupon below.

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Anaconda Metal Hose Division PE
The American Brass Company
Waterbury 20, Conn.

Please send a copy of Bulletin A-X 97

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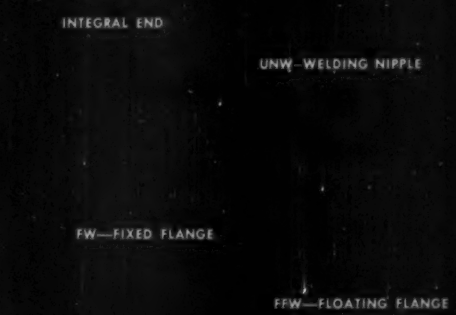
BASIC STANDARD UNIT

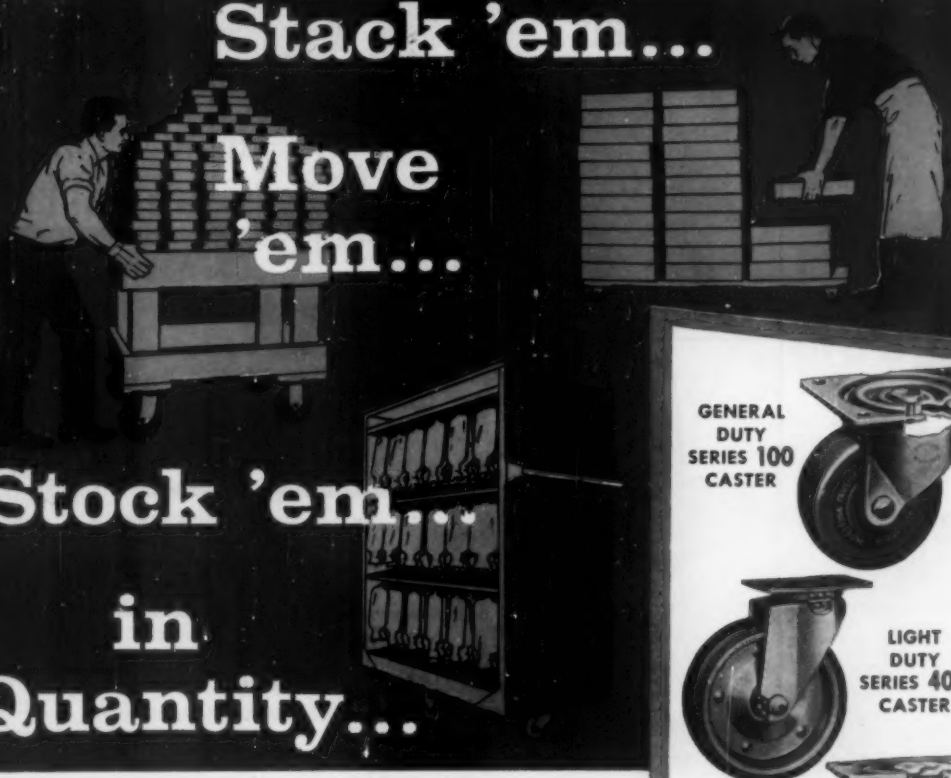
TYPES OF MOTION

FITTINGS FOR A-X TUBING—UNBRAIDED



FITTINGS FOR A-X TUBING—BRAIDED

Stack 'em... Move 'em... Stock 'em... in Quantity...



on Faultless Casters

Eliminate costly, one-at-a-time handling methods with Faultless Casters! Parts—even heavy ones—can be stacked high on Faultless Casters, ready for further processing. Fully loaded Faultless Castered trucks, carts, dollies, racks roll easily, smoothly . . . carrying your products from machine to machine, around corners, down narrow aisles, even outdoors. And products stocked on Faultless Castered equipment require minimum rehandling for packaging, or shipping. Faultless engineers a complete line of precision casters to meet your specific requirements.

ASK YOUR DISTRIBUTOR. Your nearby Faultless Industrial Distributor and the local Faultless Sales Engineer will work with you to eliminate costly one-at-a-time handling methods at your plant. Your Distributor maintains a substantial inventory of Faultless Casters for immediate delivery.

GENERAL DUTY SERIES 100 CASTER
LIGHT DUTY SERIES 400 CASTER
MEDIUM DUTY SERIES L900 CASTER
HEAVY DUTY SERIES H900 CASTER
EXTRA-HEAVY DUTY SERIES 1300 CASTER

Casters illustrated are typical of complete range of load capacities and types available for every materials handling job.

Faultless Caster Corporation
Evansville 7, Indiana

Branch Offices in principal cities; see the Yellow Pages of the telephone book under "Casters." Canada: Stratford, Ontario

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GRINDING SPINDLES

By STANDARD

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"endless versatile variations"

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PRECISION SPINDLE DIVISION

the STANDARD electrical tool co.

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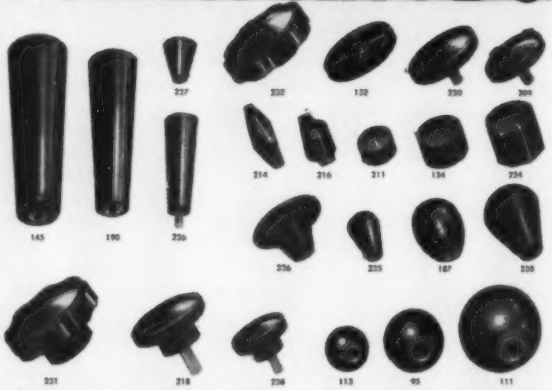

Wide selection molded plastic knobs, handles, hand-wheels at no tooling charge! Minor changes (inserts, threads, color, etc.) to suit requirements. Other modifications give your part a look of exclusive design at fraction of new mold cost! Write for complete illustrated catalog, or see Sweet's Product Design Catalog File.

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CIRCLE 641 ON READER SERVICE CARD

catalogs and bulletins.....continued

(F-86) Nickel Alloy Helical Springs—Bulletin, 46 pp. Discusses extensively composition, properties, design factors. Filled with curves and tables. Huntington Alloy Products Div, The International Nickel Co, Inc, 67 Wall St, NYC 5.

(F-87) Shock Testing Machines—Brochure, 4 pp. Impact shock testers give controlled amplitude, frequency and pulse wave form. Shocks produced range up to 2800 G's. Jan Hardware Mfg Co, Inc, 38-01 Queens Blvd, Long Is City 1, NY.

(F-88) Needle Rollers—Catalog, 12 pp. Lists sizes and gives formulas, factors and other data for design. Sizes go up to 0.3750 in. diameter. The Kaydon Engineering Corp, Muskegon, Mich.

(F-89) Guide Pins and Bushings—Catalog, 36 pp. Shows materials, construction and dimensions of pins and bushings for die sets. Lamina Dies & Tools, Inc, 14925 W Eleven Mile Rd, Oak Park, Mich.

(F-90) Wear Plates—Brochure, 4 pp. Contains dimensions of bronze plated steel side and flat wear plates. Lamina Dies & Tools, Inc, 14925 W Eleven Mile Rd, Oak Park, Mich.

(F-91) Clamping Devices—Brochure, 19 pp. Shows toggle clamps hand, air or oil operated. Gives tables of clamping forces and dimensions. Lapeer Mfg Co, 3058 Davison Rd, Lapeer, Mich.

(F-92) Springs—Catalog, 20 pp. Provides tables of specifications for coil compression and extension springs for general and instrument use. Lee Spring Co, 30 Main St, Brooklyn, NY.

(F-93) Vibration Absorption Material—Brochure, 8 pp. Describes properties and gives curves for vinyl chloride elastomeric resin pads. Shows design procedure for several types of installations. Lowell Industries, Inc, Allston Station, Boston 34.

(F-94) Coating for Stress Analysis—Bulletin, 4 pp. Describes applications and methods of determining stresses qualitatively and quantitatively. Magnaflux Corp, 7300 W Lawrence Ave, Chicago.

(F-95) Disc Springs—Handbook, 40 pp. This is a small textbook on design with belleville springs. Includes formulas, curves, sample calculations, tables for spring rates, stresses, damping, other characteristics. Adolf Schnoor KG, Stuttgart, W. Germany.

(F-96) Clutches, Brakes, Dynamometers—Brochure, 12 pp. Describes hysteresis and friction clutches, brakes and clutch-brakes with torque ratings to 300 oz-in. Also motor testing dynamometers with torque ratings to 750 oz-in. Magtrol, Iinc, 240 Seneca St, Buffalo, NY.

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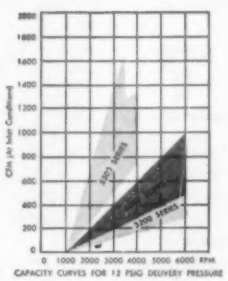

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catalogs and bulletins.....continued

(F-97) Sealed Ball Bearings—Brochure, 4 pp. Presents ball bearings under 2 in. OD with seal made of synthetic rubber bonded to metal. Marlin-Rockwell Corp, 402 Chandler St, Jamestown, NY.

(F-98) Instrument Ball Bearings—Bulletin, 4 pp. Describes precision bearings with 0.2750 to 0.5000 in. OD. Miniature Precision Bearings, Inc, Precision Park, Keene, NH.

(F-99) Transients Recorder—Brochure, 32 pp. Tells case histories of jobs handled by a machine recording up to 36 channels. Can record high frequency transients. Heiland Div, Minneapolis-Honeywell Regulator Co, 5200 E Evans Ave, Denver, 22.

(F-100) Rubber Seals—Brochure, 24 pp. Provides a guide for designing for ring seals. Gives rubber specifications, seal dimensions, applications. Minnesota Rubber Co, 3630 Wooddale Ave, Minneapolis 16.

(F-101) Oil Seals—Catalog, 92. Furnishes data on materials, selection factors and dimensions of springless and springloaded designs. National Seal Div, Federal-Mogul-Bower Bearings, Inc, Redwood City, Cal.

(F-102) Wheels and Casters—Catalog, 40 pp. Casters range from light duty to heavy industrial types. Tires are made of rubber, steel, molded plastic. The Neilson Wheel Co, 1603 N 27 St, Milwaukee, Wisc.

(F-103) Ball Bearings—Catalog, 40 pp. Lists 27 series of radial and thrust bearings. Includes bearing selection, uses and ratings. Nice Ball Bearing Co, 30 St & Hunting Pk Ave, Philadelphia.

(F-104) Digital Instruments—Catalog, 6 pp. Gives specifications for read-out display voltmeters, ratio meters and ohm meters. Also describes accessories for integrating instruments into automatic data recording systems. Non-Linear Systems, Inc, Box 728, Del Mar, Cal.

(F-105) Miniature Bearings—Catalog, 4 pp. Gives dimensions and load ratings of sintered bronze sleeve and flange bearings with bores as small as 0.0550 in. Northfield Precision Instrument Corp, 4400 Austin Blvd, Island Park, NY.

(F-106) Cams—Brochure, 12 pp. Deals with theory and uses of two and three dimensional cams. Gives design data and manufacturing techniques. The Parker-Hartford Corp, 650 Franklin Ave, Hartford, Conn.

(F-107) Precision Gears—Brochure, 4 pp. Describes range of sizes and types of custom metallic or nonmetallic gears. Perkins Machine & Gear Co, Circuit Ave, W Springfield, Mass.

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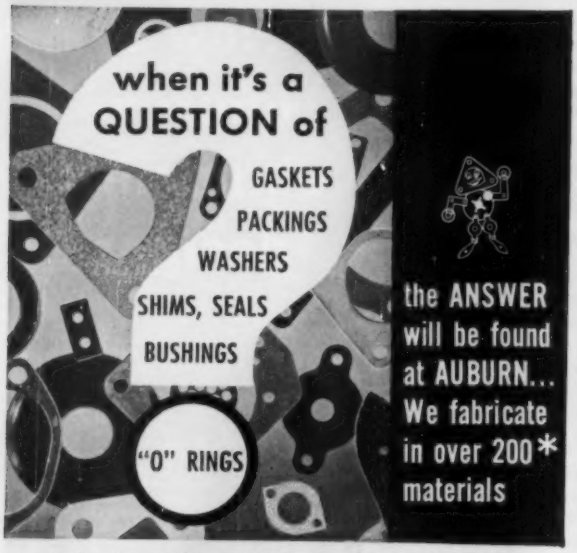

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catalogs and bulletins.....continued

(F-108) Fine Pitch Gears—Brochure, 4 pp. Provides a general discussion of definitions of terms and dimensional tolerances for commercial and precision fine-pitch gears. Pickup Precision Gear Co, 1926 Placentia Ave, Costa Mesa, Cal.

(F-109) Bronze Bearings—Catalog, 12 pp. Describes graphited and plain bronze bushings; cored and solid bronze bars. Explains lubricating from reservoir by using graphite as wick. Randall Graphite Bearings, Inc, Box 839, Lima, Ohio.

(F-110) Pillow Blocks—Catalog, 20 pp. Contains dimensions, design data for choosing graphited pillow block bearings, bearing cartridges, safety collars and mounting grommets. Randall Graphite Bearings, Inc, Box 839, Lima, Ohio.

(F-111) Servo-mechanical Parts—Catalog, 31 pp. Gives dimensional standards, specifications and applications for precision class II gearing, dials, differentials, limit stops and other servo breadboard parts. Reeves Instrument Corp, Garden City, NY.

(F-112) Magnetic Clutches and Brakes—Catalog, 8 pp. Gives dimensions, physical and electrical sepcifications for instrument types. Reeves Instrument Corp, Garden City, NY.

(F-113) Gyros—Brochure, 32 pp. Explains theory, construction and applications of single degree of freedom, floated gyros and accelerometers. Reeves Instrument Corp, Garden City, NY.

(F-114) Shock Mounting—Brochure, 4 pp. Shows some of company's shock and vibration mounting designs. Includes a vibrations nomograph. Robinson Technical Products, Inc, Teterboro Air Terminal, Teterboro, NJ.

(F-115) Oscillograph Recorders—Data folder, 40 pp. Describes 4 to 32 channel recorders, high speed optical x-y recorder, other models and accesssories covering a wide range of applications. Sanborn Co, 175 Wyman St, Waltham, Mass.

(F-116) Transducers—Data sheets, 12 pp. Furnishes specifications for transducers measuring linear velocity or displacement, pressure or pressure differential. Sanborn Co, 175 Wyman St, Waltham, Mass.

(F-117) Magnetic Shaft Seals—Brochure, 4 pp. Shows rotating seals which use magnetic force instead of springs to maintain rubbing contact. Magnetic Seal Corp, 166 Bay Spring Ave, W Barrington, RI.

(F-118) Ball Joints—Brochure, 12 pp. Describes types for mechanical linkages; throttle, transmission and steering controls. Superior Ball Joint Corp, Trier Rd, Ft Wayne, Ind.

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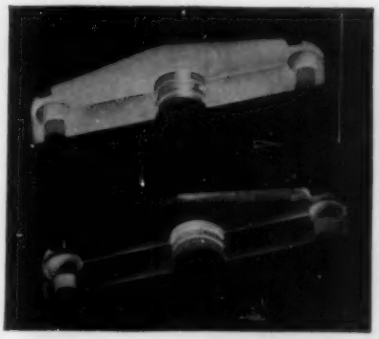

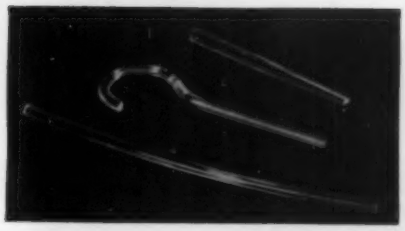

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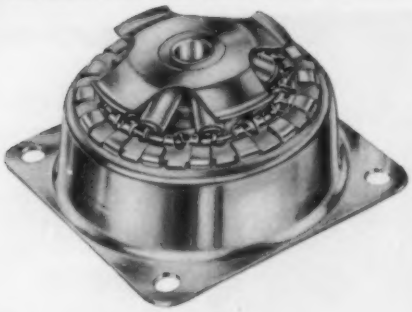

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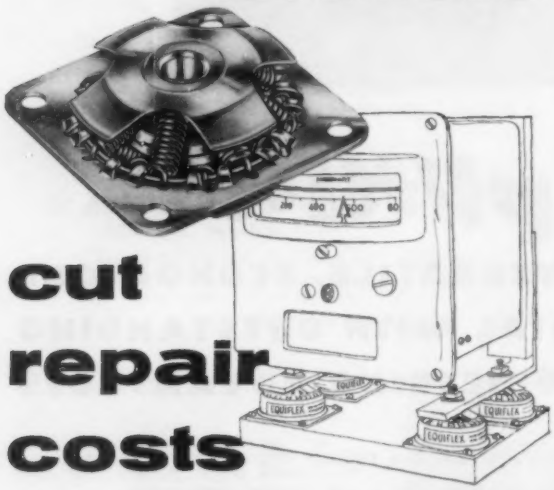

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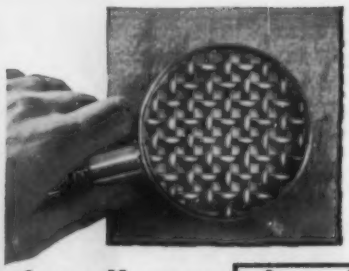

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CIRCLE 649 ON READER SERVICE CARD

catalogs and bulletins.....continued

(F-119) Way Bearings, Lead Screws—Two bulletins, 6 pp. Gives capacities and dimensions of recirculating roller type bearings. Also recirculating ball lead screw. Scully-Jones & Co, Special Products Div, 1928 S Rockwell St, Chicago 8.

(F-120) Bellows Seals—Bulletin, 4 pp. Describes a face type seal with wide temperature latitude. Sealol, Inc, Providence 5, RI.

(F-121) Mechanical Seals—Bulletin, 12 pp. Describes seal suitable for pumps, compressors, other equipment in petrochemical and high temperature service. Sealol, Inc, Providence 5, RI.

(F-122) Mechanical Seal—Bulletin, 8 pp. Provides dimensions of face type seal and recommended dimensions of utilizing equipment. Sealol, Inc, Providence 5, RI.

(F-123) Transducers—Brochure, 4 pp. Describes pressure transducers, pressure switches and translation potentiometers. Servonic Instruments, Inc, 640 Terminal Way, Costa Mesa, Cal.

(F-124) Latches—Catalog, 30 pp. Presents a drawing aid with housings and fittings arranged interchangeably on facing pages. Simmonds Aerocessories, Inc, 105 White Plains Rd, Tarrytown, NY.

(F-125) Belleville Springs—Catalog, 9 pp. Gives materials, standards, explanation of designing with spring washers. Solon Mfg Co, 32300 S Miles Rd, Solon 39, Ohio.

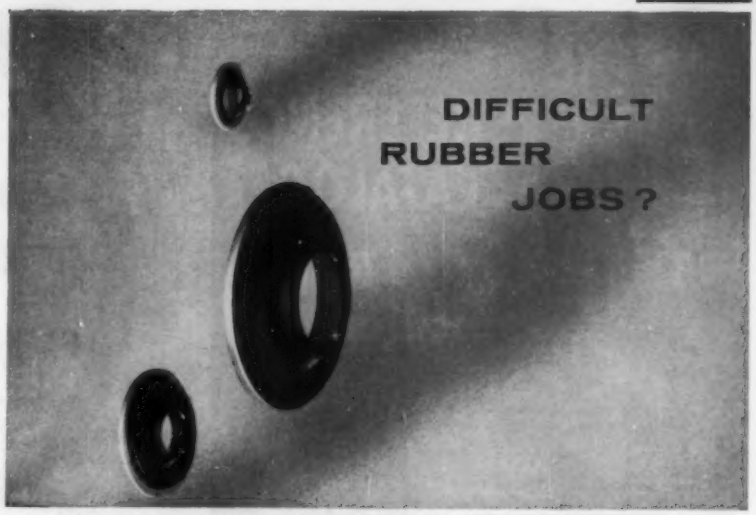
(F-126) Test Laboratory—Brochure, 6 pp. Illustrates equipment used in qualification, reliability, environmental and product evaluation testing of aircraft and missile components. Stellardyne Laboratories, Inc, Box 337, El Cajon, Cal.

(F-127) Inertial Guidance Test Equipment—Catalog, 24 pp. Rate turntables have oil or air bearings. Other equipment includes gyro test sets, computer and data recorder, counters, accessories. Sterling Precision Corp, Instrument Div, 17 Matinecock Ave, Port Washington, NY.

(F-128) Automatic Test Equipment—Brochure, 24 pp. Explains operation of solid-state electronic equipment for missiles, aircraft, ground electronic equipment which automatically administers programmed test, records and analyzes results. Stromberg-Carlson Div of General Dynamics Corp, 100 Carlson Rd, Rochester, NY.

(F-129) Rubber Mounts and Bushings—Catalog, 12 pp. Describes machinery and instrument mounts, bushings and bearings, all using rubber between inner and outer metal sleeves. The General Tire & Rubber Co, Industrial Products Div, 1218 Garfield St, Wabash, Ind.

continued



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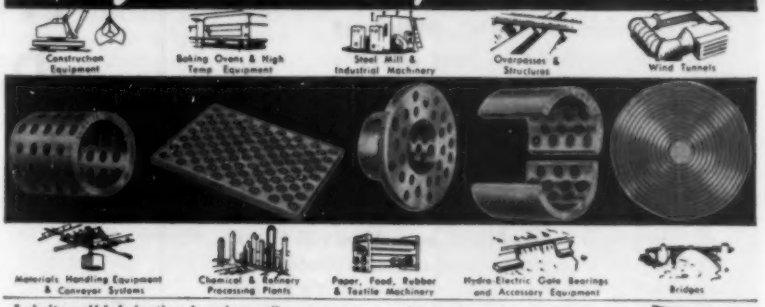
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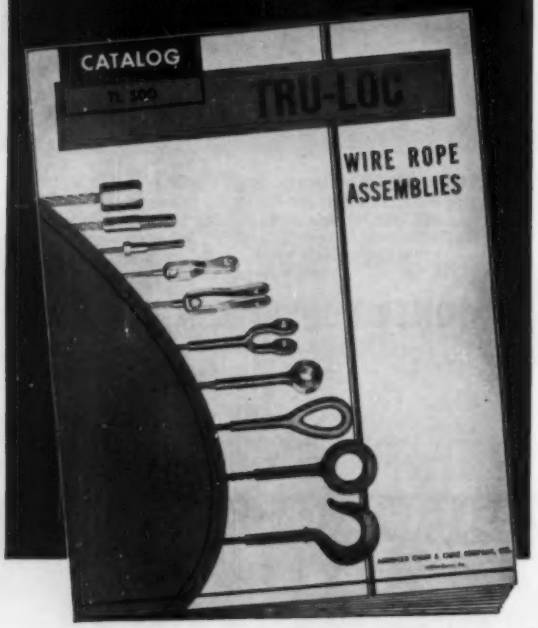

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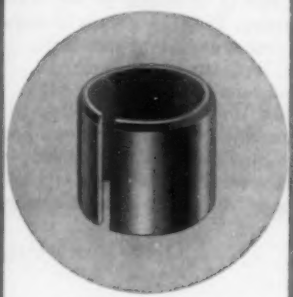

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(F-134) Ball Bushings—Catalog, 20 pp. Provides specifications, installation data, and load ratings for linear motion applications. Thomson Industries Inc, Manhasset, NY.

(F-135) Roller Bearings—Bulletin, 6 pp. Tabulates dimensions of heavy duty bearings. Speed, life and load calculations shown. The Torrington Co, 59 Field St, Torrington, Conn.

(F-136) Mist Lubricator—Bulletin, 4 pp. Explains centralized system and proper selection for installation conditions. Trabon Engineering Corp, 28815 Aurora Rd, Solon, Ohio.

(F-137) Nuclear Instrumentation—Catalog 64 pp. Describes such instruments as counters, spectrometers, detectors, sample changers and others. Tracerlab Inc, 1601 Trapelo Rd, Waltham, Mass.

(F-138) Tensile Testing Instruments—Catalog, 92 pp. Illustrates and describes a wide range of machines and attachments for determining physical properties of all kinds of materials. Tested properties include: tensile strength, elongations, hysteresis or fatigue, plasticity, flexing, twist, bursting and others. Scott Testers Inc, Providence 1, RI.

(F-139) Oil Seals—Catalog, 99 pp. Provides tables of dimensions, engineering data and installation instructions for leather and rubber cased oil seals. Albert Trostel Packings, Ltd, Lake Geneva, Wisc.

(F-140) Seals—Brochure, 4 pp. Shows dimensions, tolerances for static and dynamic seals lathe-cut from polymers. Also gives groove and piston dimensions to guide design. Acadia Synthetic Products, 4035-4117 Ogden Ave, Chicago 23.

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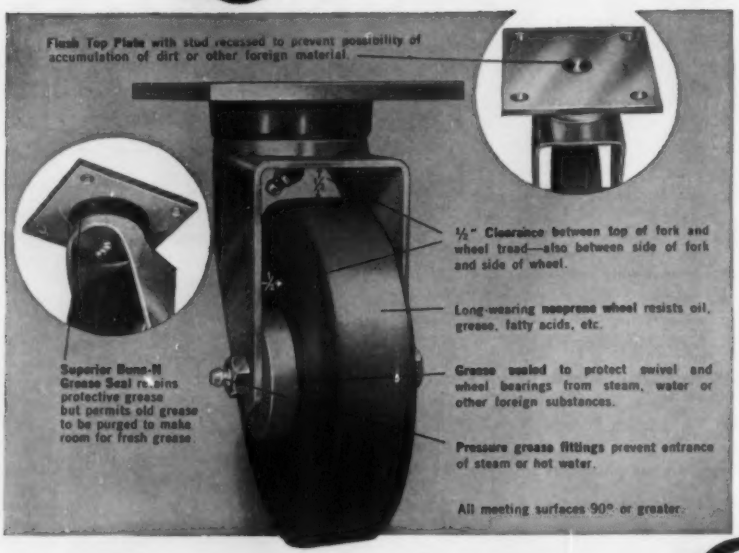
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(F-142) Instrument Probes—Catalog, 20 pp. Describes many types of temperature and pressure probes, traversing units, mercury slip rings. Discusses formulae and methods for their use. United Sensor & Control Corp, 122 Naubuc Ave, Glastonbury, Conn.

(F-143) Fluid Flow Instrumentation—Catalog, 85 pp. Provides dimensioned drawings, curves for pressure and temperature probes, rakes, gas sampling and traversing probes, traversing units and others. Discusses sample installations and theory. United Sensor & Control Corp, 122 Naubuc Ave, Glastonbury, Conn.

(F-144) Fine Pitch Precision Gears—Handbook, 92 pp. Presents tables of spur gears 48 to 200 pitch; bevel gears 48 to 72 pitch; servomotor gearheads; servomotor gearhead assemblies. Includes dimensions, prices, specifications. US Gear Corp, 81 Bay State Rd, Wakefield, Mass.

(F-145) Motion Transducers—Catalog, 43 pp. Describes functioning of ac type displacement transducers. Provides data and uses for variable reluctance and differential transformer types. Vinson Engineering & Sales Corp, 8044 Woodley Ave, Van Nuys, Cal.

(F-146) Strain Gages—Brochure, 4 pp. Describes strain gages, load cells, force gage, position transducer. Waldale Research Co, Inc, 362 W Colorado Blvd, Pasadena, Cal.

(F-147) Thrust Bearings—Catalog, 14 pp. Provides curves of operating data, and dimensions of tilting pad type bearings up to 45 in. OD. Waukesha Bearings Corp, Box 346, Waukesha, Wisc.

(F-148) Recording Oscillograph—Bulletin, 16 pp. Gives details on basic oscillograph and accessories. Shows scope of uses in recording transients. Electro Mechanical Instrument Div, Consolidated Electrodynamics Corp, 260 Sierra Madre Villa, Pasadena, Cal.

(F-149) Stellite Bushings, Sleeves—Brochure, 12 pp. Outlines properties; illustrates uses in corrosive or abrasive service. Haynes Stellite Co, Div of Union Carbide Corp, 1020 W Park Ave, Kokomo, Ind.

(F-150) Electromanometer—Bulletin, 4 pp. Describes system of precision pressure balance and a servoamplifier to furnish outputs suitable for visual readout, process control or analog input. Transducer Div, Consolidated Electrodynamics Corp, 360 Sierra Madre Villa, Pasadena, Cal.

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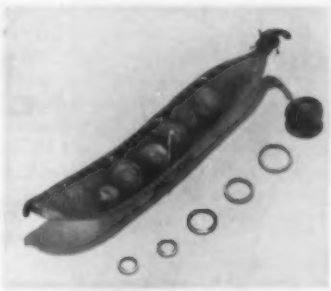

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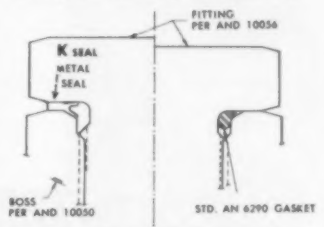

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(F-152) Environmental Test Equipment—Catalog, 26 pp. Machines simulate temperature, altitude, humidity, vibration, shock and combinations of these. Most equipment is portable. Wyle Mfg Corp, 133 Center St, El Segundo, Cal.

(F-153) Instrumentation—Brochure, 4 pp. Describes instrumentation and accessories for shock and vibration, high intensity sound, pressure, temperature and others. Guilton Industries, Inc, Guilton Instrumentation Div, 212 Durham Ave, Metuchen, NJ.

(F-154) Sliding Journal Bearings — Brochure, 4 pp. Gives a general idea of centrifugally babbitted journal, thrust, self-aligning and other type bearings company makes. Waukesha Bearings Corp, Commerce & Pearl Sts, Waukesha, Wisc.

(F-155) Small Parts — Bulletin, 10 pp. Shows variety of zinc alloy die cast and thermoplastic molded parts. Includes gears, bobbins, fasteners, clamps, ferrules and many others. Gries Reproducer Corp, 159 Beechwood Ave, New Rochelle, NY.

(F-156) Roller Bearings—Catalog, 97 pp. Provides tables of dimensions along with drawings and typical installations. Includes radial, thrust and self-aligning bearings, pillow blocks and some equipment using these bearings. Messinger Bearings, Inc, D St above Erie Ave, Philadelphia.

(F-157) Lightweight Ball Bearings—Catalog, 12 pp. Furnishes tables of dimensions and load ratings for bearings with ID's from 2 to 60 in. Includes load and life calculations. Messinger Bearings, Inc, D St above Erie Ave, Philadelphia.

(F-158) Self-lubricating Products—Catalog, 60 pp. Describes bushings, bearings, pillow blocks and slip-ring assemblies using a self-lubricating combination of graphite and various metals. Includes material characteristics and bearing design data. Graphite Metallizing Corp, 1024 Nepperhan Ave, Yonkers, NY.

(F-159) Self-aligning Bearings—Catalog, 40 pp. Drawings accompanied by tables give dimensions and load ratings. Bearing bores go up to 6 in. Includes rod ends with self-aligning bearings. Southwest Products Co, 1705 S Mountain Ave, Monrovia, Cal.

(F-160) Seals—Brochure, 4 pp. Spring-loaded shaft seals are for corrosive as well as noncorrosive liquids and slurries. Chemical & Power Products, Inc, 11 Broadway, NYC 4.

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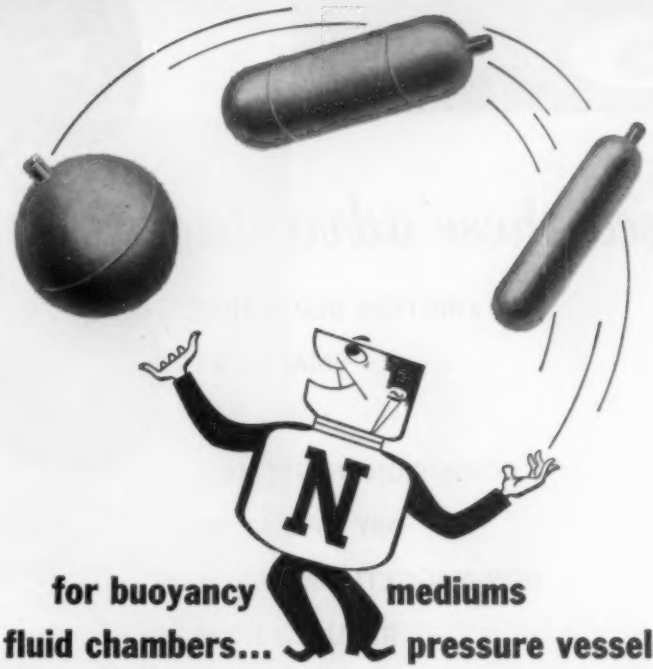

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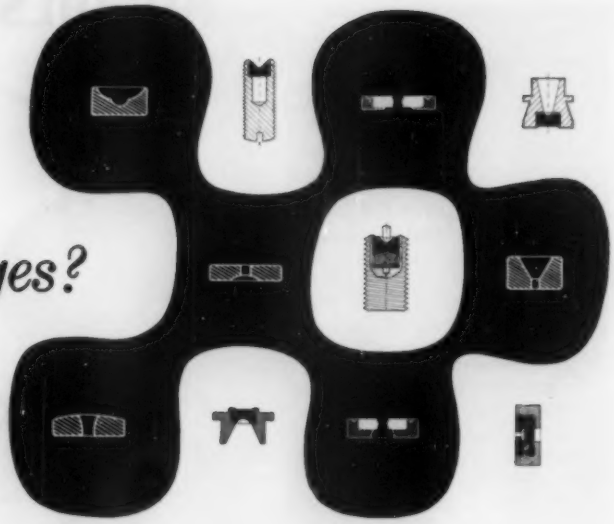

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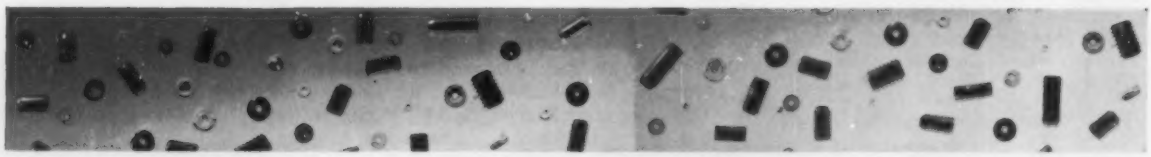

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SECTION G

FASTENING AND JOINING

Design Abstracts 336

How to Design for Blind Riveting
by Charles E. Heilig, Jr. 338

How Rings Aid Design
by Howard Roberts 343

Fastener Torque: How Much?
by John A. Stevenson 346

18 Ways to Join Honeycomb Panels
by Frank J. Filippi and Boris Levenetz 348

DESIGN ABSTRACTS

ULTRASONIC WELDING OF ALUMINUM

In this process, high-frequency electrical energy is converted to ultrasonic mechanical energy, which introduces shear vibration between the parts being joined. A solid-state metallurgical bond is produced over about half the width of the weld with the balance being a mechanical bond. Aluminum alloys in gages from about 0.00025 to 0.125 in. can be welded to themselves as well as to other metals. Ultrasonic welds in annealed aluminum are comparable in strength to resistance spot welds. In cold-worked and heat-treated sheet, however, ultrasonic welds are much stronger because they do not contain any low-strength cast or heat-affected zones. No surface preparation is required except for the removal of heavy annealing or heat-treating films.

Welding conditions vary greatly, ranging from less than 100w for 0.01 sec when welding thin foil to 4000w for several seconds when welding 0.090-in. sheet. By far the most important joining condition is the ultrasonic frequency, which must be closely tuned to the resonant frequency of the welding array to obtain strong joints.

"Ultrasonic Welding of Aluminum," F. R. Collins, J. D. Dowd and M. W. Brennecke, Alcoa Research Laboratories, New Kensington, Pa. Welding Journal, October 1959, 20th and Northampton Streets, Easton, Pa.

*

Welding Nodular Iron Castings

Many excellent articles have been written concerning the weldability of cast-iron materials. In general, however, preheats over 1000F and involved procedures have been recommended which present difficulties to the production welder when large parts are involved. As a result of tests it has been found that sound welds can be produced in restrained joints of nodular cast iron or gray cast iron using the shielded metal-arc process with the commercially available 55Ni-45Fe electrodes and a preheat temperature of 600F.

The most satisfactory technique found for producing welds with a minimum of porosity was one which employed a stringer-bead technique using an arc length of about $\frac{1}{8}$ in. A minimum amount of weld penetration is desirable and necessary to obtain porosity-free welds.

"Process Welding of Nodular and Gray Iron Castings," Benjamin Townshend and Ellis O. Porter. Welding Journal, August 1959, 20th and Northampton Streets, Easton, Pa.

*

Foil-seam Welding

A foil-butt-seam weld is made by butting together the edges of the parts to be joined and passing this joint between roller electrodes in the conventional manner except that a thin, narrow strip of steel is introduced above and below the joint as it enters the roller electrodes. This strip or foil is usually $\frac{1}{4}$ to $\frac{5}{8}$ in. wide and 0.010 in. thick. The primary functions of the foil are that it: Serves to concentrate the welding current in the immediate area of the weld joint; contains the plastic weld metal and prevents expulsion; serves as a bridge to distribute the welding current evenly between the two sheets; prevents too rapid withdrawal of heat from the work; gives a slightly raised weld bead as opposed to the excessive indentation at the joint line experienced without foil; offers a slight resistance at the weld line thus contributing to welding heat.

"Butt Welding Steel Sheet by the Foil-seam Process," L. W. Mecklenborg, Precision Welder & Flexopress Corp, Cincinnati, Ohio. Welding Journal, January 1960, 20th and Northampton Streets, Easton, Pa.

*

Furnace Brazing Techniques

Furnace brazing consists of heating an assembly of metal parts in a furnace in a reducing atmosphere. A brazing medium of proper shape and analysis is placed adjacent to each connecting part in the assembly that is to be brazed. The brazing medium melts during the heating operation, wetting the surface and creeps along the surface until drawn into and through each joint by capillary attraction, alloying with the parent metal of the parts being joined. Any excess of the brazing medium usually forms a neat fillet along the joint, adding to the strength of the joint. Following the heating in the furnace, the assembly is cooled while still in the reducing atmosphere, in a cooling hood which is attached to and forms an integral part of the furnace equipment. Furnace brazing is capable of producing a high quality product—at low cost—from a minimum of material.

"Furnace Brazing Techniques." Bulletin No. 592, The Electric Furnace Co, Salem, Ohio.

*

Bolt Bending Stresses

Although screws and bolts are designed chiefly for axial loads, they are often subjected to bending or shearing stresses. Where this occurs, the design must include some means of overcoming these stresses.

There are four basic solutions for this problem: Dowel pins, dowel bolts, bushings, intermeshing component shapes. These solutions are examined.

"Bolt Bending Stresses," Federico Strasser, Santiago, Chile. Design Engineering, April '60, 481 University Ave, Toronto, Canada.

*

Fastener Standards

Each of the organizations that issues standards for general-purpose fasteners is discussed, and its method of operation described. In addition, each of the types of standards prepared by the various groups included are listed and described. Standards of the American Standards Assn ASTM, US Government, SAE and the Industrial Fasteners Institute are presented.

"Here's the Score in Fastener Standards." Fasteners, Vol 1, No 4. Industrial Fasteners Institute, 1517 Terminal Tower, Cleveland 13.

*

Fatigue-resistant Riveting

This paper concentrates on the techniques of increasing fatigue

strength of riveted structures by removing rather than adding weight. Gives design procedures, test results, effects of various kinds of stress, and a list of seven design tips. Drawings of the riveted joints discussed in paper and curves giving data obtained from fatigue tests are included.

"Designing Fatigue-resistant Strucstures," C. R. Smith, Convair, Div General Dynamics Corp; ASTM paper 76. American Society for Testing Materials, 1916 Race St, Philadelphia 3.

*

Fasteners—Six Ways to Save Money

Six areas where standardization on certain types and sizes of fasteners should reduce purchase costs and inventories are discussed: thread series, class of fit, bolts vs. studs, head style, material specifications, and plating specifications.

"Six Easy Ways to Save Money in Fasteners," F. E. Graves, Russell, Burdsall & Ward Bolt & Nut Co. American Standards Assn, Inc, 70 E 45th St, New York 17.

*

Welding Nickel Alloys

Covers fusion and resistance welding of the more familiar age-hardenable wrought alloys. Based on materials obtained from files of Defense Metals Information Center at Battelle Memorial Institute. Includes bibliography of available literature.

"The Welding of Wrought Age-hardenable Nickel-base Alloys for Service at Elevated Temperatures," DMIC Memorandum 38; Defense Metals Information Center, Battelle Memorial Institute, Columbus 1, Ohio.

*

Welding of Foil

Inert-gas-shielded tungsten-arc welding is particularly adaptable for the welding of butt joints in foil. However, careful consideration of a number of process variables is essential. Only by control of these variables through good design of all components of the welding equipment can foils of 0.002-, 0.003-, and 0.005-in. thicknesses be welded.

Accurate preparation of the joint edges is essential to achieve successful welds. Shearing, slitting and milling techniques are discussed with respect to their applicability to edges for welding.

"Control of Process Variables—Key to the Successful Welding of Foil," John Campbell, Central Research Laboratories, Air Reduction Co, Murray Hill, NJ. Welding Journal, Dec '59, 33 W 39th St, New York 18.

*

Screw or Bolt?

"You say that this is a cut-thread screw and that's a rolled-thread screw. Just what's the difference?"

"Well, first of all, when I said it was a cut-thread screw I didn't really mean that the thread was cut. Actually, it was rolled on that thread roller over there. You see, it's really a rolled thread, but we call it a cut thread because. . ."

Confused? Admittedly, this bit of conversation is fictional, but it points out a serious problem—industry's failure to standardize on terminology. Especially is this true of the older branches of industry; the fastener industry is a prime example. It's here you'll find the cut thread that is rolled; the debate as to what is a screw and what is a bolt; terms whose origins are by now obscure; and individual products that can be specified (and priced!) in a number of ways.

Does a solution exist? It won't be a quick or easy task, but several steps have already been taken. Just recently, Russell Burdsall & Ward Bolt and Nut Co, Port Chester, NY, published a revised list of fastener nomenclature.

"A Screw is Not a Bolt—Or is It?" American Machinist/Metalworking Manufacturing, February 22, 1960, 330 W 42nd St, New York 36, NY.

*

Fastening Magnesium

The current and prospective use of magnesium sheet has posed a need for an improved fastener material.

A shear strength and galvanic corrosion evaluation of both high-purity and commercial-purity aluminum alloys (5052, 6061 and 5056 types) as a fastener for magnesium alloys indicates the excellent performance of high-purity 5056 alloy in both room- and elevated-temperature service. The unexpectedly high shear strength exhibited by this material further enhances its position as a rivet alloy for this service. Concomitantly, a reduction of heavy metal impurities in this alloy results in a high degree of galvanic compatibility with magnesium which does not suffer on prolonged elevated temperature aging.

"For Fastening Magnesium, High-Purity Aluminum Alloy Rivets," J. L. Nichols, Metallurgical Laboratory, The Dow Metal Products Co. Magnesium Topics, October 1959, The Dow Chemical Company, Midland, Michigan.

*

Semi-tubular Rivets

This schedule covers the body diameter and head dimensions for three head styles of semi-tubular rivets. Heads include: Oval head—semi-elliptical head having a flat bearing surface, a table shows rivet proportions; trust head—low rounded top surface with a flat bearing surface which is larger in diameter than an oval head, a table shows proportions; flat countersunk head—flat top with a 150 degree conical bearing surface, tables show proportions. General data: Bearing surface for the oval and truss head rivets shall be at right angles with the body within 2 deg. Eccentricity of the rivet head to the shank, unevenness of the tubular end, surface seams or other imperfections shall not be such that the usability of the rivet will be impaired. Radius of the fillet under the head of oval and truss head rivets shall not exceed the values in table. Materials of semi-tubular rivets shall be low carbon steel (0.1 of 1 per cent carbon or less), commercial yellow brass, copper, aluminum and other materials as agreed upon between purchaser and supplier.

"Dimensional Standards for Semi-tubular Rivets." The Tubular and Split Rivet Council, 53 Park Place, New York 7, New York.

From: American Machinist

how to design for . . . BLIND RIVETING

23 design details plus 48 checkpoints for assembly methods.

CHARLES E. HEILIG, JR.
"Pop" Rivet Div.
United Shoe Machinery Corp.
Shelton, Conn.

No single joining process or fastener can provide a universal answer to all assembly problems. Intensive study is necessary to evaluate one against another. If one method or fastener has an overriding advantage for the part in question, then a detailed analysis is unnecessary. Table I lists the advantages of 10 fasteners and processes.

Too frequently, however, some factors are omitted during an evaluation. The modifications that are necessary in plant and facilities are overlooked. Actual in-place cost is not determined, and choice made on fastener cost alone.

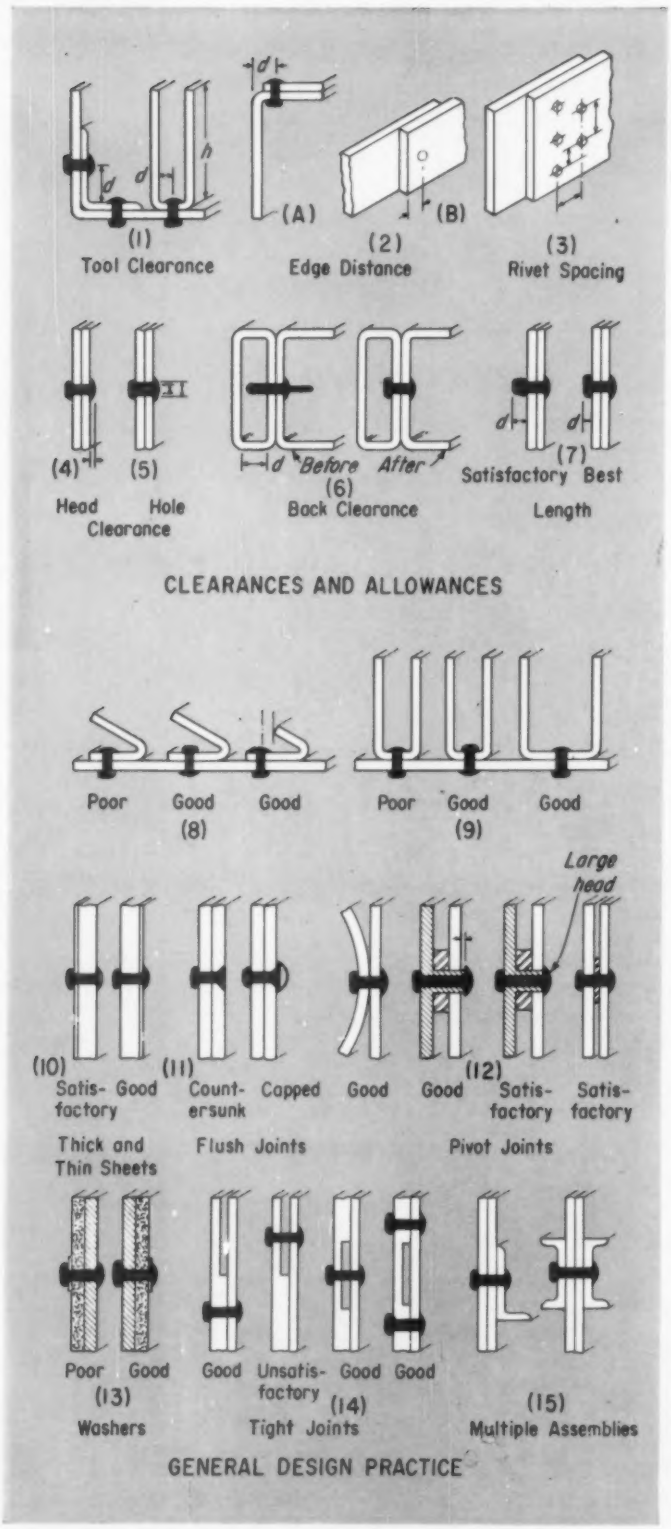
There are three, and possibly four main areas that should be considered when determining which method is best for you: (1) Effect on plant and facilities; (2) design advantages and requirements; (3) production advantages and requirements; and (4) service requirements, which actually should be considered under design. Some of the most important points in each of these areas are listed under "Assembly Analysis," Table II. This type of study, along with a factual cost analysis, cannot help but reveal the best fastener or method for the application.

TABLE I—ADVANTAGES OF 10 FASTENING METHODS

TYPE OF FASTENING	PRINCIPAL ADVANTAGES
Blind rivets	1. Tools are portable 2. Easily removed 3. Semi-automatic feed frees operator's hand 4. Covers wide panel range with same rivet size
Drive-pin blind rivet	1. Hammer is only assembly tool needed 2. Solid rivet, good in shear 3. Tamperproof 4. No secondary operation required
Solid rivets	1. Unit cost not high 2. High-strength joints, good in primary structure 3. Uniform appearance on both sides of work 4. Large variety of styles and sizes of heads
Tubular or semi-tubular rivets	1. Low rivet cost 2. Fast installation 3. More than one rivet can be set per cycle 4. Good appearance on both sides of work
Screws in tapped holes	1. Simple replacement of assembly 2. High grip strength 3. Reusable 4. Assembly can be made from one side of work
Sheet-metal screws	1. Low initial fastening cost 2. Standardized tools available 3. Easily removable 4. Can be assembled from one side of work
Nuts, bolts, lockwashers	1. High installed strength 2. Suited for low and high volume production 3. Installed with standard tools 4. Hole size not critical
Wire stitching	1. Low fastener cost 2. No holes required 3. Fast setting time and automatic machines 4. Holds soft material to metal well
Welding (spot or resistance)	1. No holes required in mating parts 2. No fastener to handle 3. Speed of operation 4. Can be a strength joint
Adhesives	1. No holes required 2. Back-up space not necessary 3. Sealed joints 4. No electrolytic corrosion problem

REFERENCE:
An Engineer's Guide to Blind Riveting Practices by Charles E. Heilig, Jr, "Pop" Rivet Div, United Shoe Machinery Corp, Shelton, Mass. Published in American Machinist, Sept 7, 1959, p 137.

DESIGN DETAILS OF BLIND-



Clearances and Allowances

(1)—Tool Clearance . . . Minimum allowable distance from a wall or projection to the rivet-hole centerline is critical, should be checked against tool specifications. Depth of a channel or cylindrical section likewise limits the application if the rivet is inserted as shown. However, tool extensions can often be employed, and the nosepiece of the tool can be extended by as much as an inch.

(2)—Edge Distance . . . From the standpoint of joint strength, the recommended distance from the rivet centerline to the edge of a sheet should not be less than twice the rivet diameter. If joint strength is secondary, this dimension can be greatly reduced. Example: the rivet functions only to hold a bracket or component in position.

(3)—Rivet Spacing . . . This also is a function of application and strength requirements.

(4)—Head Clearance . . . Standard head dimensions vary with rivet size. Height and diameter can readily be determined from specification sheets. Frequently, the work can be countersunk, or the joint designed to prevent interference with mating sections.

(5)—Hole Clearance . . . Permissible clearance depends on whether the fastener grips the wall or clinches underneath. In the latter case, oversized holes are less critical, and one does not depend on wall constriction to prevent breakout.

(6)—Back Clearance . . . Distance from flat of the head to end of the unclinched rivet determines the required back clearance—not dimensions after setting. These values should take into account the maximum combined material thicknesses.

(7)—Rivet Length . . . There is a delicate balance between joint thickness, mandrel-head dimensions, the cold-working properties of the rivet material and, of course, the shank diameter of a blind rivet. On the other hand, one length can be used for a wide range of panel thicknesses. For any use beyond the tabulated data, actual limitations should be determined by test.

General Design

(8)—Angles and Formed Sections . . . Avoid obstructions to the tool, which should set flush on the work. Thus, the "poor" joint requires a special offset tool, may still be inaccessible. Reverse the rivet and set from the other side, or reduce the length of the angular section.

(9)—Channel Sections . . . For adequate tool clearance, set from the underside of the channel or widen the section. A tool extension may be used to reach inside the section, but makes the tool somewhat more awkward to handle.

(10)—Thick and Thin Sheets . . . If there's a choice, it's best to set the rivet against the thicker material. Rivets of this type can be set against 0.030 in. and thinner aluminum stock.

(11)—Flush Joints . . . A truly flush surface can be obtained only by countersinking the outer wall or plate. Dimpling generally is not recommended because of the possibility of the rivet not fully "bottoming" and setting against the hole edge. A smooth, watertight, but not completely flush surface is obtained by countersinking and capping the rivet.

TABLE II ANALYSIS OF VARIOUS COMMON AND SPECIALTY ASSEMBLY METHODS

Checkpoints	COMMON FASTENING AND JOINING METHODS														SPECIALTY FASTENERS			
	Sheet-metal Screws		Nuts/Bolts/ Lockwashers		Solid Rivets		Tubular/ Semi Tubular		Blind		Resistance Welding		Adhesives		Other		Stapling/ Stitching		Drive Pin Screws	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
1. Is large capital investment required?		X		X		X		X		X	X		Depends on curing methods and cycle					X		X
2. Are locating fixtures necessary?	X			X	X		Depends on assembly			X	Depends on product		X					X		X
3. Must multiple tools or equipment be purchased?		X		X		X	X			X	X			X			X		X	
4. Is present floorspace adequate?																				
5. Is process or fastener adaptable to all metalic materials?		X	X		X		X		X			X		X			X		X	
6. Can dissimilar materials be joined?	X		X		X		X		X		Within narrow limits		X				X		X	
7. Can nonmetallic materials be joined?		X	Generally not desirable			X	X		X			X	X				X			X
8. Can thin sections be joined?		X	Generally not economical		X		X		X		X		X				X		X	
9. Can heavy sections be joined?		X	X		X		X		X			X	Generally not recommended					X		X
10. Can unequal thicknesses be joined?	X		X		X		X		Within specified limits		Within narrow limits		X				X			X
11. Can blind sections be joined?	X				X	X		X	X			X	X					X	X	
12. Can method or fastener be used for sections with limited back clearance?	X				X	X		X	X			X	X					X	X	
13. Can multiple parts be assembled?	X		X		X		X		X			X	X					X		X
14. Are fasteners available in various materials and finishes?		X	Materials only		Materials only		X		X								Materials only			X
15. Is a wide range of diameters and lengths available?	X		X		X		X		X									X		X
16. Is grip strength high?		X	X		X			X	X		X		X					X		X
17. Is compressive strength high?	X		X		X		X		X		X		X				X		X	
18. Is shear strength high?	X		X		X		X		X			X		X				X		X
19. Is tensile strength high?		X	X					X		X		X		X				X		X
20. Will joint have smooth or flush appearance?		X		X		X	X		X		X		X					X		X

20. Will joint have smooth or flush appearance?		X		X		X		X		X		X		X				X		X		
21. Will joint withstand vibration?												X										
22. Will projections catch objects or clothing?			X			X		X			X			X				X		X		
23. Will joint be weathertight?												X										
24. Is assembly tamperproof?												X										
25. Is field assembly practical?													X									
26. Can product be dismantled for maintenance or repair?													X									
27. Is fastener cost higher or lower than average?	Lower		Higher than most		About Average		Lower than most		About Average		No fastener		Depends on resin				Lower than most		About Average			
28. Is in-place or joint cost higher or lower than average?	Lower		Higher		Very high		Lower		Lower		Higher						Lower		Lower			
29. Is fastener or process adaptable to high-speed production?	X			X		X	X		X		X		X									
30. Is fastener or process adaptable to short or broken run production?	X		X		X	X	X		X		X		X									
31. Must materials be cleaned prior to assembly?		X		X		X		X		X	X		X					X	X			
32. Are special services (air, water, power) required?		X		X	X			X		X	X			X					X			
33. Must products be punched or drilled?	X		X		X		X		X			X		X			X					
34. Are secondary machining operations (tapping, countersinking) necessary?		X	Depends on requirements		Depends on requirements			X		X		X		X					X	X		
35. Are hole dimensions critical?	X		X		X		X			X		X		X			X					
36. Must joining be performed prior to finishing (pointing, plating)?		X		X	X			X		X	Depends on process		X				X	X	X			
37. Are secondary finishing operations necessary (deburring, grinding)?		X		X		X		X		X	X			X			X		X			
38. Can fastening or joining process be performed during assembly?	X		X			X	X		X			X	Usually not. Depends on product					X				
39. Will assembly operations damage finish or coating?	X			X	X			X		X	X		X						X			
40. Is all-position assembly practical?	X		X		X			X	X			X	X					X				
41. Can fastener be fed automatically?	X			X		X	X		X										X			
42. Is panel thickness critical?	X		X		X		X			X	X			X				X				
43. Will tools reach confined sections?		X		X		X		X	X			X					X		X			
44. Can more than one joint be made simultaneously?		X		X		X	X			X	X		X				X		X			
45. Must work be transported to tools (i.e. is tool location fixed)?		X		X	Depends on equipment		X			X	X			X					X			
46. Can product be damaged during joining or assembly?	X		X			X		X		X	X			X					X			
47. Is machine setting difficult?				X		X		X		X	X			X			X		X			
48. Must skilled operators be employed?				X	X			X		X	X		X				X		X			

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RIVETED JOINTS

(12)—Pivoted Joints . . . Method at left is satisfactory for low-cost consumer products where some binding can be tolerated until the joint works in. The one shown second from the left is perhaps best, because there is some small clearance between the rivet head and the wall.

(13)—Washers . . . If a metallic section is to be assembled to a softer material, a washer may be necessary to provide the necessary rigidity for clinching action. The soft material should be outside with the washer under the rivet head. For conventional assemblies either way is practical.

(14)—Tight Joints . . . Since blind rivets exert considerable gripping force when clinched, the joint shown second from left is impractical. Conversely, either of examples in which a single rivet is employed may prove as satisfactory as the one with multiple rivets.

(15)—Multiple Assemblies . . . One, two or more components or sections can be riveted to a base or panel with a single rivet, provided they can be mounted from the front, or the base section is accessible from the rear or underneath.

(16)—Straps and Clamps . . . A blind rivet can be used to assemble straps, clamps, and similar members around a component. Allowance must be made for the squeezing action on the clamp.

(17)—Housings and Panels . . . Of the many ways to construct a housing or panel, the ones shown here are perhaps the most common. Examples: left —a double-channel section forming the joint to which the panels are assembled and riveted; center —a back-up stringer with a finishing strip inserted between mating panels; right—a base angle with riveted panels and a finishing strip between the gap. In selecting the design, consider cost, appearance, strength and thermal expansion.

(18)—Weatherproof Joints . . . It's difficult to produce a pressure-tight riveted joint, but reasonably moisture resistant, weather-tight assemblies have been evolved.

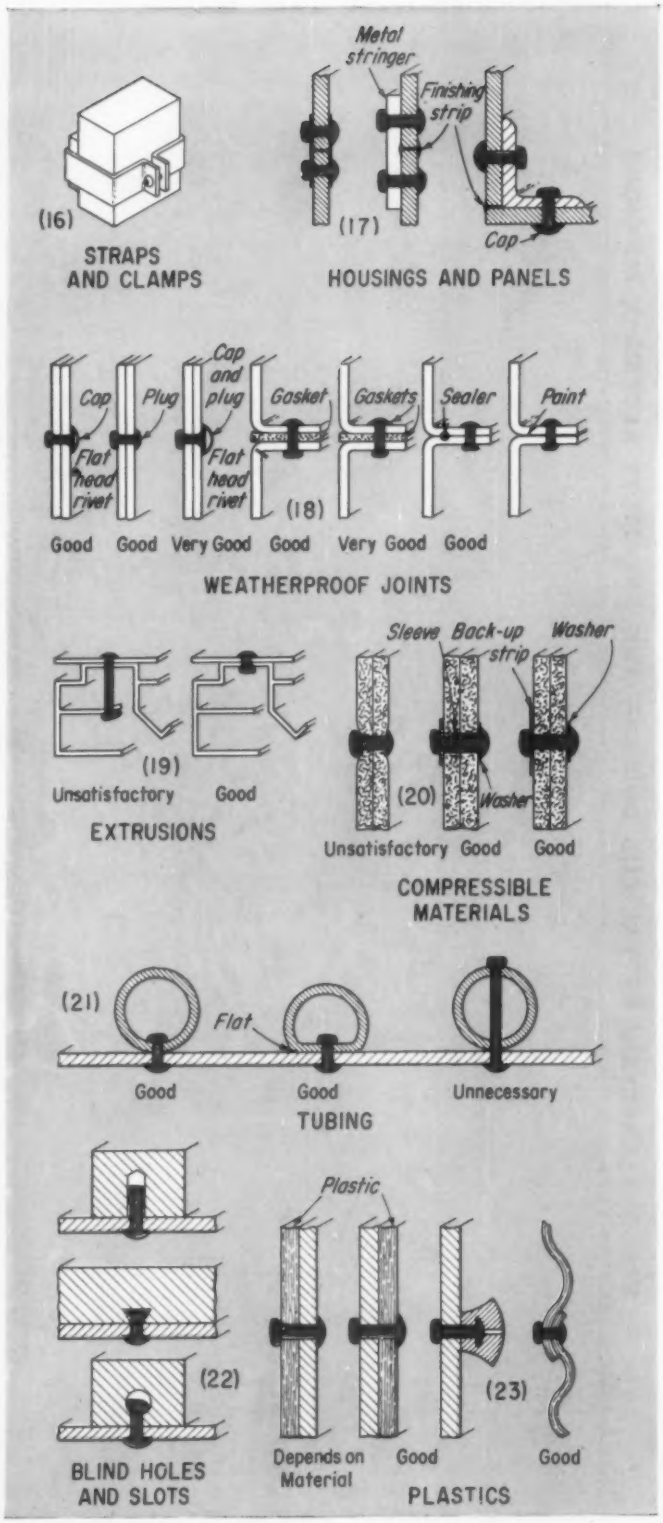
(19)—Extruded Sections . . . Blind riveting is common, because of the limited access and clearances in most extruded sections. Rigidity of the joint at right is far greater than that at left. Setting against unsupported internal projections is seldom recommended.

(20)—Compressible Materials . . . Compressible materials do not provide a firm base for the setting action, and the rivet may tear through. Use of a formed sleeve or bushing, or a washer and back-up plate can solve this problem.

(21)—Tubing . . . For maximum rigidity, the rivet should not extend through both walls of tubular members. The rivet will set blind against the curved inner wall section, or the tubing can be flattened to increase the contact area.

(22)—Plastic Members . . . Preferably, the rivet should be set against a metallic rather than a plastic member. However, the rivets are being set successfully against many molded and extruded plastics, which resist setting pressure without cracking.

(23)—Blind Holes or Slots . . . Clinching the rivet against the side of a blind hole or into and against a milled slot, intersecting hole, or internal cavity is possible because of the clinching action of the rivet.



From: Electronics

HOW RINGS AID COMPONENT DESIGN

Retaining rings that satisfy many different fastening requirements are tabulated.
Formulas aid in calculating design loads.

HOWARD ROBERTS
Manager of Engineering Services
Truarc Retaining Rings Div.
Waldes Kohinoor, Inc.
Long Island City, New York

Component design can be simplified with retaining rings. The number, size and weight, complexity of components in an assembly can be reduced. Thus rings are ideally suited to electronic applications where miniaturization and lower manufacturing costs are design objectives.

FASTENING REQUIREMENTS

Because stamped retaining rings are essentially hard tempered springs, their shearing strength and their thrust and impact capacity, is high. Most rings are seated in deep grooves; this lets the fastener support greater loads.

Self-locking rings, which do not require grooves, are useful for assemblies in which the ring will not be subjected to any sizable thrust, but rather must serve as a positioning or locking device.

The rings are easy to assemble and disassemble with simple hand tools and often can be installed with mechanized equipment. The fasteners often eliminate threading, tapping, drilling and other costly and time-consuming machining operations. Accurate location of ring grooves, which usually can be cut simultaneously with other production processes, assures precise seating of components in the assembly, and minimizes binding or end-play.

Some of the most widely used standard rings are shown in Table I. For some applications, rings are available in sizes to accommodate shafts as small as 0.040 in. in diam. Except for certain self-locking types, all rings are reusable following disassembly.

RING APPLICATIONS

Table II lists the materials from which most retaining rings are manufactured, together with their shear strength and temperature limits. In selecting rings for individual applications, a number of factors should be considered. Size, loading conditions, clearance and method of assembly and disassembly are most important when selection is made in the design stage.

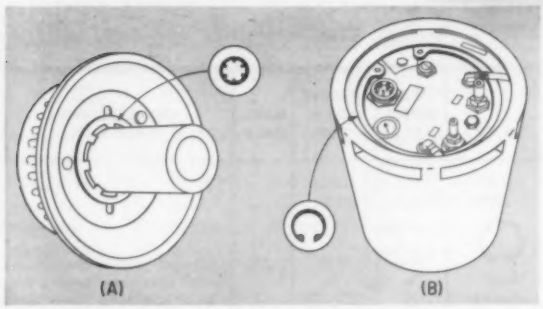


Fig. 1—Knob assembly (A) uses circular self-locking ring to position and lock dial skirt on plastic knob shaft. Push-on type ring is installed without groove, accommodates tolerances of plastic parts to eliminate end play. Portable industrial X-ray unit (B) uses beveled internal ring to lock end plate of transformer tube housing.

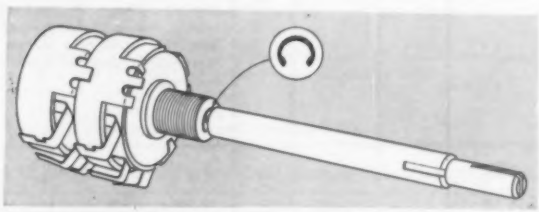


Fig. 2—Radially-assembled crescent ring locks threaded ferrule on potentiometer shaft. Low shoulder, uniformly concentric with shaft, provides clearance necessary for assembly of panel locknut. Ring may be removed easily and reused.

Formulas for calculating safe design loads are given in Table III. For maximum thrust capacity under both static and dynamic loading conditions, the abutting face of the retained part should have a square corner. The retained part should permit reasonably concentric uniform loading against the ring.

Rings with inverted lugs provide a shoulder which is uniformly concentric with shaft and housing. Inverted rings are useful for retaining parts with large corner radii, such as those found on bearings, or chamfers.

Of the radially assembled types, crescent rings are best for clearance. E-rings and reinforced E-rings provide a large shoulder on small diameter shafts. The bowed locking-prong ring is useful for taking up end-play and for providing spring tension on retained parts. The two-part interlocking ring is intended for assemblies in which the ring will be subjected to high rpm's or when the retained parts rotate at varying speeds relative to the ring. The circular push-on types are ideal for plastic studs and fiber tubes.

STANDARDS

Stamped retaining rings are covered by a number of Government and industry standards. These include Department of Defense Military Standards MS 16624 through MS 16634 and MIL-R-21248; and National Aircraft Standards NAS 669-670, which supersede NAS 50-61. The rings also have been assigned various Federal Stock Number Classifications. Figures 1 and 2 below illustrate the use of retaining rings on actual assemblies. Rings replace screws and shim washers, eliminate tapping of studs, reduce size and overall height of units.

TABLE I Design, Characteristics and Applications of Retaining Rings

TYPE	SIZE RANGE (IN.)	THRUST LOAD[a] (LBS)	MATERIALS[b]	CHARACTERISTICS, APPLICATION
AXIAL ASSEMBLY TYPES				
Basic internal	1/4 to 10	350 to 220,200	CS BC PB SS AL	Tapered section assures constant circularity, groove pressure. Withstand heavy thrust loads, high rpm's. Used widely to retain bearings and cover plates in synchro motors, servo mechanisms; position windings on resistors. Bowed and beveled types take up endplay. Used to pretension tuning shafts preload bearings, retain tube sockets, lock nulling slugs in synchro housings.
Basic external	1/8 to 10	110 to 220,200		
Inverted internal	3/4 to 4	1,650 to 34,200	CS BC PB SS AL	Inverted lugs and increased section height provide better clearance, higher shoulder uniformly concentric with housing or shaft. Used to retain cover plates, shielded bearings, ball and roller bearings, other parts with large corner radii or chamfers.
Inverted external	1/2 to 4	1,100 to 34,300		
RADIAL ASSEMBLY TYPES				
Crescent external	1/8 to 2	85 to 7,300	CS BC PB SS AL	Narrow, tapered section provides low shoulder uniformly concentric with shaft. Used in potentiometers, recording instruments, other assemblies where clearance is critical.
E-Ring external	0.040 to 1-3/8	13 to 4,100	CS BC PB SS AL	Functions as large shoulder on small diameter shafts. Retains hinge pins, springs, linkages, tuner shafts, position precision gears in small gear drives. Bowed ring available for end-play take-up.
Reinforced E-ring external	3/32 to 7/16	50 to 600	CS BC PB SS AL	Provides greater gripping power, higher rpm limits than conventional E-rings. Resists heavy vibration and shock loads, relative rotation.

TYPE	SIZE RANGE (IN.)	THRUST LOAD[a] (LBS)	MATERIALS[b]	CHARACTERISTICS, APPLICATION
Locking prong external	3/32 to 7/16	80 to 700	CS BC SS	Prongs prevent ring from being forced out of groove. Bowed construction provides spring tension for end-play take-up. Retains tuner shafts, other control devices in radios, TV sets, tape recorders, other instruments.
Interlocking external	15/32 to 3-3/8	2,000 to 43,500	CS BC PB SS AL	Two-part ring designed to withstand high rpm's. Provides shoulder uniformly concentric with shaft. Used for retaining bearings in high-speed motors, applications in which parts rotate at varying speeds, relative to ring.
SELF-LOCKING RINGS				
Circular external	3/32 to 1	27 to 220	CS BC SS	Push-on type fastener. Prongs lock ring on shaft against movement in one direction. Retains small sockets, hinge pins, linkages, other components which normally do not have to be removed for field servicing or maintenance.
Circular internal	5/16 to 2	45 to 150	CS BC SS	Used in bores and housings. Secure against movement in one direction. Holds caps in capacitors, similar applications where ring must function as positioning and locking device.
Grip ring external	5/64 to 3/4	10 to 90	CS BC PB SS	For ungrooved shafts, tubes, bosses, die-cast and plastic studs. Locks against movement from either direction. Adjustable after assembly and re-usable. Replaces setscrew collars, cotter pins. Ideal for components which must be removed for servicing, maintenance.

TYPE	SIZE RANGE (IN.)	THRUST LOAD[a] (LBS)	MATERIALS[b]	CHARACTERISTICS, APPLICATION
Triangular external	1/16 to 7/16	25 to 270	CS BC	Dished body. Prongs lock against shaft under spring pressure. Accommodates moderate tolerances, heavy thrust loads. Holds laminates in position in transformers, also retains medallions and ornaments to chassis.
Triangular nut external	Thread Series 6-32 to 1/4-28		CS BC	Dished body flattens under torque. Eliminates need for lock washers. Secure against moderate impact, vibration. Used on control devices to hold screw settings.
SPECIAL TYPES FOR ELECTRICAL USE				
Terminal external	31/32	3,200[c]	BC	Inner tab locks ring on shaft. Large tab serves as wire shoulder, contact or terminal.
Coil shoulder external	5/16 to 1/2	Ring usually used on plastic or fiber tubes. Thrust capacity not a factor	BC	External ring used as coil shoulders. Elongated lugs serve as terminals; inner tab locks ring on tubular shaft.
Detent spring internal	1-1/16	5,000	CS	Internal ring without lugs. Acts as precision detent spring. Notches facilitate assembly, disassembly.

TABLE I — RINGS ARE AVAILABLE in sizes to accommodate shafts as small as 0.040 in. in diam. for some applications. The basic internal and external rings are ideal for applications in which the fasteners will be subjected to heavy thrust loads or high rotational speeds. If it is necessary for the ring to take up end-play caused by accumulated tolerances or wear in the retained parts, bowed or beveled rings should be considered. Bowed rings provide resilient end-play take-up. Beveled rings, which are installed in grooves with a corresponding bevel on the load-bearing wall, act as a wedge to provide rigid take-up. Available finishes are given in Table II.

a — Pr (See Table III) Value for carbon spring steel rings, installed on shaft or in housing made of hardened steel, with properly mating parts.

b — See Table II.

c — Value for beryllium copper ring.

TABLE II—Materials and Finishes Used in Rings

BASIC MATERIAL[a]	SHEAR STRENGTH, PSI	TEMP. LIMITS, DEG F	REMARKS
Carbon Spring Steel (CS)	120,000 to 150,000[b]	−100 to +650[b]	800 to 900 F, use 2/3 P_r[d] 1,200 F, 3/10 P_r
Beryllium Copper (BC)	82,000 to 110,000[c]	−100 to +650	800 to 900 F, use 2/3 P_r
Phosphor Bronze (PB)	48,000 to 60,000	−42 to +212	Not recommended for use above 212 F
Stainless Steel (SS)	120,000 to 150,000[b]	−100 to +900	At 1,000 to 1,100 F use 2/3 P_r

a Available in variety of protective or decorative finishes
b Varies according to ring size
c Varies according to ring style
d Allowable thrust load of ring (See Table III)

TABLE III—Formulas for Calculating Safe Design Loads

Definition of Terms	Type of Stress	Formula
a — acceleration of parts (in/sec²) d — groove depth (in) E — modulus of elasticity of groove material f — frequency, cps F — safety factor[a] h — largest section of ring (in.) I_g — allowable impact load on groove, in-lb I_r — allowable impact, load on ring, in-lb. P_g, P_r — allowable static thrust load on groove or ring, lb P_{rr} — allowable rotating thrust load on ring exerted by adjacent part, lb S — shaft or housing diameter, in. s — working stress of ring under maximum expansion or contraction, psi s_s — ultimate shear strength of ring material, psi s_y — tensile yield strength of groove material, psi t — ring thickness, in. T — acting load, lb w — weight of retained parts, lb δ — deflection, in. μ — coefficient of friction (dry parts 0.15–0.20) ρ — amplitude, in.	Static thrust load on ring	$P_r = \frac{St\pi s_s}{F}$
	Static thrust load on groove	$P_g = \frac{Sd\pi s_y}{F}$
	Impact loading on ring	$I_r = \frac{P_r d}{2}$
	Impact loading on groove	$I_g = \frac{P_g d}{2}$
	Vibration loading on ring	$wa \leqq 540 P_r$
	Vibration loading on groove	$wa \leqq 400 P_g$
	Harmonic oscillation for ring or groove	$a \leqq 40\rho f^2$
	Allowable thrust load on ring when retained part rotates relative to ring	$P_{rr} \leqq \frac{sth^2}{\mu 18S}$
	Elastic deformation (temporary displacement of retained part under load)	$\delta = \frac{T}{Ed}$

a. Varies with ring design and material. Value is 4 for basic steel internal and external rings.

REFERENCE:

How Rings Aid Design by Howard Roberts, Manager of Engineering Services, Truarc Retaining Rings Div, Waldes Kohinoor, Inc, LI City, N. Y. Published in Electronics, Nov 20 '59, p 88.

From: Fasteners

FASTENER TORQUE: HOW MUCH?

Suggested maximum torque values for fasteners of 7 different materials, up to 1½ in.-dia thread.

JOHN A. STEVENSON
Manager
Technical Sales
The H. M. Harper Co.

The question is often asked: Why is there no reliable data on torquing values? Why do existing recommendations carefully carry the warning "use at your own risk"?

The often heard answer is that there are too many variables involved. This is not just an excuse, we feel it is an honest fact—a very real stumbling block to publishable data.

VARIABLES REVIEWED

The fastener material itself is a definite variable, but an often overlooked one. Table I shows that torque values differ with various materials. Consequently, where a high torque is desired the choice of material is important.

The material variable also brings on the added function of heat treating of product to the extent that torquing loads can be more than doubled. If all materials responded to manufacturing methods in a like manner, and if all similar products were manufactured identical equipment, this would be true. The relationship of torque and tensile strength would be proportionate.

However, certain materials work harden at different rates. For instance, an austenitic stainless steel or silicon bronze bolt will increase in strength through cold forming and roll threading considerably more than common steel or brass. Furthermore, the identical bolt can be made more than one way. Consequently, varying degrees of material work hardening are introduced. For example, an extruded product will normally have a higher tensile value than a non-extruded fastener—the same would apply to a roll-threaded versus a cut-threaded fastener. However, even though controlled testing shows work hardening to increase torque values, the increase is not as great as is realized in tensile values. It is felt that this difference stems from the fact that work hardening effects the fastener core least, and that the torque component most simulates a shearing action where the material center is the last failing element.

Since fastener torque is, to a great extent, the force that will overcome friction, consider thread lubrication as a variable—as well as the less often considered variables of foreign matter in the threads, surface condition of mating parts, class of fit, etc. These variables will add to the actual torque needed to tighten down the fastener. Because this resistance-torque is not added into the recommended torquing values, they should be either eliminated or compensated for. If it is not accounted for, the recommended torque reading will be less than anticipated by the amount of torque, by the tight fit, the foreign material, or the thread burr, etc.

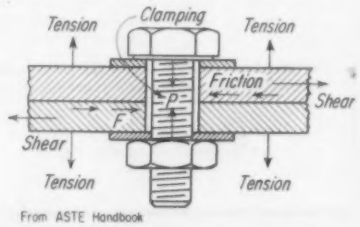
Conversely, an oil or wax lubricant will give a higher reading than anticipated because the lubricant reduces the force needed to overcome the normal friction expected on mating threaded parts. For example, tests show that a wax-lubricated ¼-20 24S T-4 aluminum bolt will break at 65 in.-lb, while it takes 100 in.-lb to break the same product in the dry condition. Consequently, unless the fact that a fastener product is lubricated is taken into account, over-torquing may result. To a similar degree, both anodizing (as it pertains to aluminum) and plating will also reduce resistance-torque and increase the torque reading over the normal "as threaded" recommended values.

One formula that can be used as a rough guide for dry steel nuts and bolts is

$$T = CDF$$

where

T = torque, in. lb
C = torque coefficient, approx. 0.2 for dry steel
D = bolt dia, in.
F = bolt tension required, lb



From ASTE Handbook

This will supply the torque required to develop a predetermined tensile load in the product. The 0.2 represents a theoretical but fully evaluated figure for torque coefficient, and is derived from an assumed coefficient of friction of 0.15.

The torque table included here holds bolt tension at a factor somewhat less than the yield point of the fastener. Ordinary dial type torque wrench equipment was used in plotting torque value curves. The product was torqued to failure in all cases, thus proving the safety factor built into the above formula. Cold-rolled steel plates of varying thicknesses were used. The product was inserted through fractional-sized holes, no washers were used underneath the head but were at the nut end. Plates were selected that would bring the fastener under tension at a point where the nut would be approximately mid-way along the threaded section.

The maximum torque values recommended for low carbon steel fasteners as shown in this table are derived from results obtained in the P. A. Sturtevant Company laboratory, adjusted to conform to actual tests made at the H. M. Harper Company. These latter tests furnished yield point torquing values. These, in turn, were reduced by 35% in order to correlate the values with the formula results. The carbon steel values reflect a slight adjustment downwards from calculated torquing loads.

Similarly, the Harper Company's fastener stock, composed of six materials, was evaluated and plotted against the original carbon steel curve. Although the results were not as close, in comparison, as were the carbon steel tests, they were similar enough to plot the values shown in the table for the material given.

Tests were conducted on dry, or near dry, product. Mating parts were wiped clean of chips and foreign matter. The $\frac{3}{8}$-in.-dia product, and under, was roll-threaded and, where size range permitted, was made on bolt-maker equipment.

REFERENCE:

A Guide to What Torque a Fastener Should Have by John A. Stevenson, Manager, Technical Sales, The H. M. Harper Co, Morton Grove, Ill. Published in Fasteners, Winter, 1959, p. 6.

TABLE I—Maximum Torque Values

Bolt size	Low carbon steel	18–8 Stainless steel	Brass	Silicon bronze	Aluminum 24ST-4	316 Stanless steel	Monel
	in.-lb	in.-lb	in.-lb	in.-lb	in.-lb	in.-lb	in.-lb
2–56	2.2	2.5	2.0	2.3	1.4	2.6	2.5
2–64	2.7	3.0	2.5	2.8	1.7	3.2	3.1
3–48	3.5	3.9	3.2	3.6	2.1	4.0	4.0
3–56	4.0	4.4	3.6	4.1	2.4	4.6	4.5
4–40	4.7	5.2	4.3	4.8	2.9	5.5	5.3
4–48	5.9	6.6	5.4	6.1	3.6	6.9	6.7
5–40	6.9	7.7	6.3	7.1	4.2	8.1	7.8
5–44	8.5	9.4	7.7	8.7	5.1	9.8	9.6
6–32	8.7	9.6	7.9	8.9	5.3	10.1	9.8
6–40	10.9	12.1	9.9	11.2	6.6	12.7	12.3
8–32	17.8	19.8	16.2	18.4	10.8	20.7	20.2
8–36	19.8	22.0	18.0	20.4	12.0	23.0	22.4
10–24	20.8	22.8	18.6	21.2	13.8	23.8	25.9
10–32	29.7	31.7	25.9	29.3	19.2	33.1	34.9
1/4″–20	65.0	75.2	61.5	68.8	45.6	78.8	85.3
1/4″–28	90.0	94.0	77.0	87.0	57.0	99.0	106.0
5/16″–18	129	132	107	123	80	138	149
5/16″–24	139	142	116	131	86	147	160
3/8″–16	212	236	192	219	143	247	266
3/8″–24	232	259	212	240	157	271	294
7/16″–14	338	376	317	349	228	393	427
7/16″–20	361	400	327	371	242	418	451
1/2″–13	465	517	422	480	313	542	584
1/2″–20	487	541	443	502	328	565	613
9/16″–12	613	682	558	632	413	713	774
9/16″–18	668	752	615	697	456	787	855
5/8″–11	1000	1110	907	1030	715	1160	1330
5/8″–18	1140	1244	1016	1154	798	1301	1482
3/4″–10	1259	1530	1249	1416	980	1582	1832
3/4″–16	1230	1490	1220	1382	958	1558	1790
7/8″–9	1919	2328	1905	2140	1495	2430	2775
7/8″–14	1911	2318	1895	2130	1490	2420	2755
1″–8	2832	3440	2815	3185	2205	3595	4130
1″–14	2562	3110	2545	2885	1995	3250	3730
	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb
1 1/8″–7	340	413	337	383	265	432	499
1 1/8″–12	322	390	318	361	251	408	470
1 1/4″–7	432	523	428	485	336	546	627
1 1/4″–12	396	480	394	447	308	504	575
1 1/2″–6	732	888	727	822	570	930	1064
1 1/2″–12	579	703	575	651	450	732	840

From: SAE Paper

18 ways to JOIN HONEYCOMB PANELS

A design guide to aid selection among mid-panel and panel-rib joints, spar-panel intersections, and edge-member attachments.

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Ever-increasing use of honeycomb-sandwich structures in many different products, including missiles, has revealed a lack of basic design information for these structures. The designer's problem is always: What is the best way to join panels without sacrificing much of their strength?

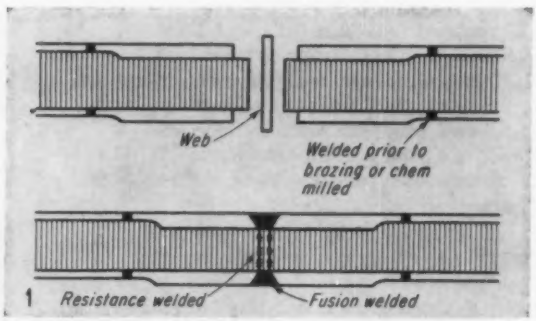
There are two basic approaches to joint design: The pictorial design approach, used extensively; and the analytic design approach, used less because of lack of time. The pictorial design procedure is mainly concerned with optimizing one type of structure such as honeycomb sandwich. Analytic design seeks to achieve the best load transfer at the lightest weight, irrespective of the type of structure necessary to accomplish the transfer. In this digest the pictorial approach is presented. In any joint design, however, productibility is the major factor influencing final selection. The design engineer must recognize that his skills are currently at the mercy of the production engineer who must reduce the design to a producible article at a reasonable cost.

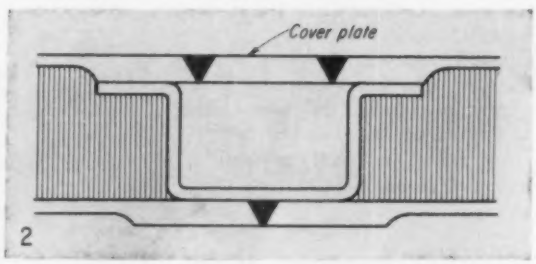
MID-PANEL JOINT

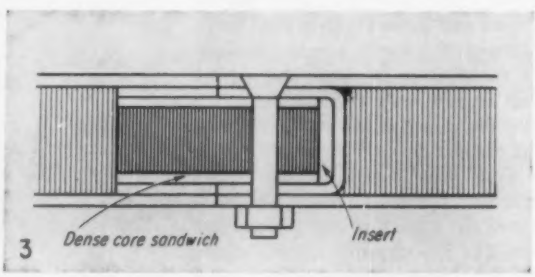
A mid-panel joint must be designed to carry bending, shear, compression, and tension loads. The shear loads require connection of the panel cores, since the core is the only element able to transmit shear forces perpendicular to the panel. For applications not involving shear loads, joining the cores is not mandatory, but is very desirable for joint stabilization. The ideal joint would have cores and faces welded together, providing necessary ties for proper load transfer. It can not, however, be produced because of inaccessibility of the core for welding. A producible and analytically satisfactory joint, Fig. 1, shows the joint before the welding operation as prepared for joining. The now-accessible core is welded to the web, the joint is closed, and a fusion weld picks up the faces and web. The addition of the web guarantees a good shear joint for the core, while the thickened facing compensates for the loss in strength from the fusion welding operation. Although some deformation of the core is encountered, good shear transfer is still possible.

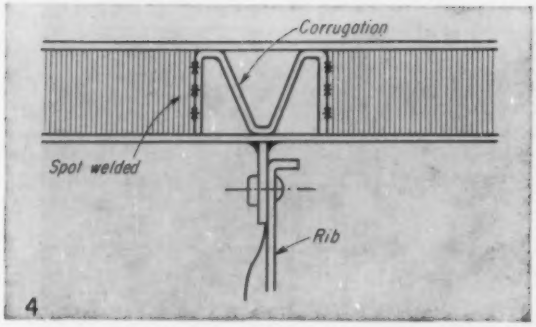
Much of the brazed honeycomb sandwich manufactured today is made from precipitation-hardenable stainless steels. As a result of heat treatment, these steels exhibit a net growth averaging 0.004 in. per in. Unfortunately, the fact that this growth is neither consistent nor exactly predictable results in dimensional discrepancies of the heat-treated parts. Machining a panel edge before welding gives a measure of compensation for erratic growth and should be considered as necessary design practice along at least two adjacent edges of any precipitation-hardenable steel sandwich.

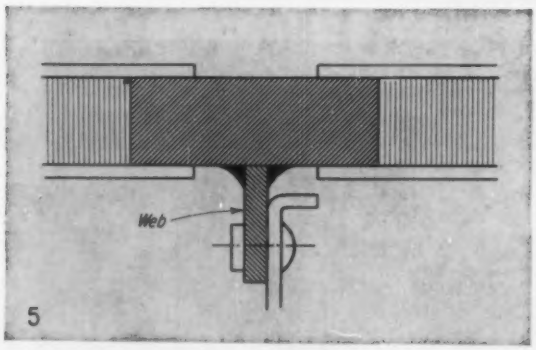
Where welding access is from one side only, the joint

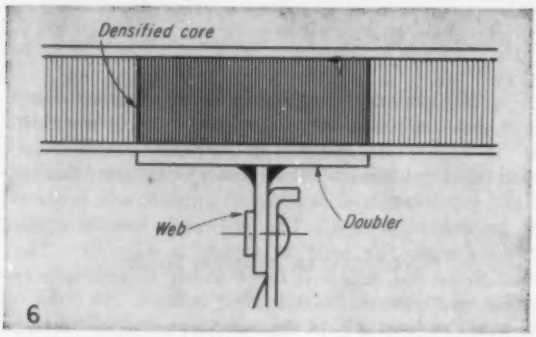


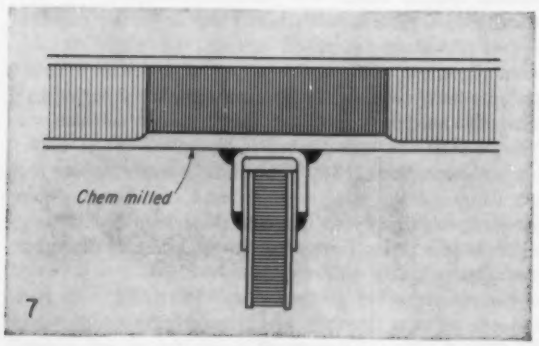


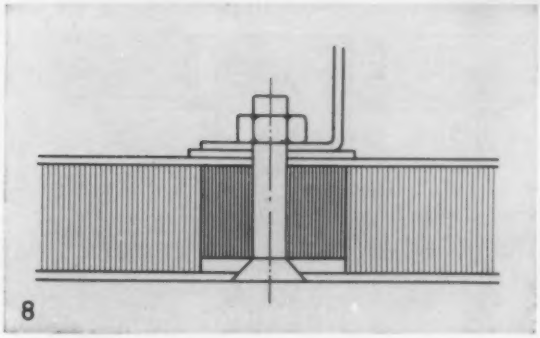


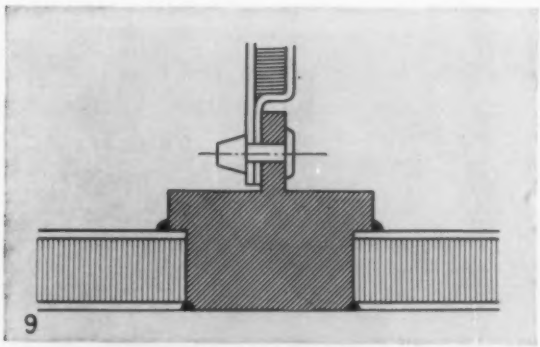


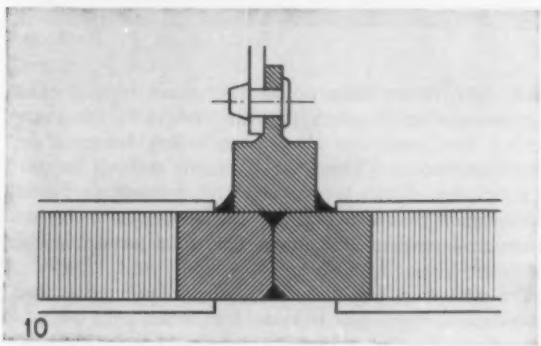










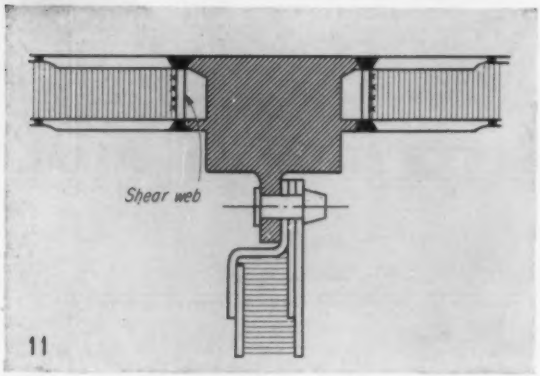


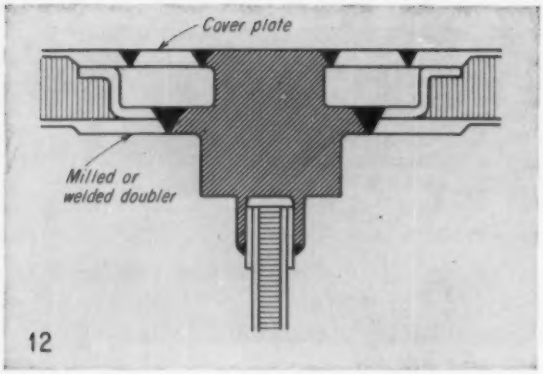
becomes more cumbersome. A solution is presented in Fig. 2 that is satisfactory except for the incumbent weight penalty. The panels are brazed with the edge members extended beyond the net part size and trimmed to final size. Within limits, growth compensation is possible with this joint. Welding the cover plate to the panels as the last operation completes the joint.

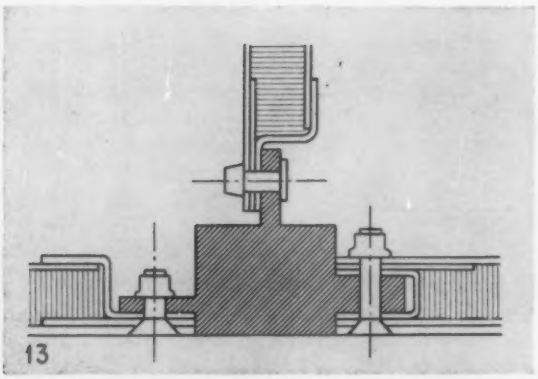
A mechanical joint, admittedly heavier yet, is shown in Fig. 3. Essentially a tongue-and-groove joint, the tongue portion is a sandwich bar of densified core, its faces designed to carry the longitudinal loads of the panels. The bar may be mechanically attached, or brazed in place as shown. The mating portion of the joint is brazed with a U-channel edge member through which the mechanical attachment is made.

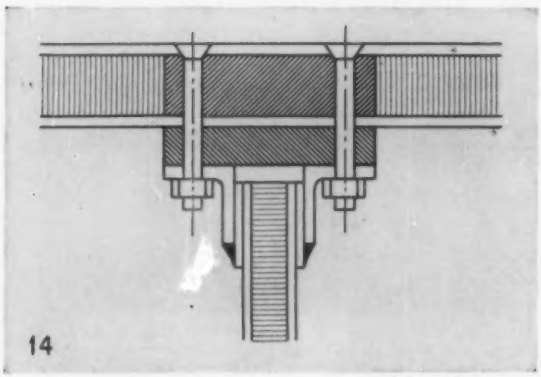
PANEL-RIB JOINT

The panel-rib joint must maintain the integrity of the original panel and transfer any additional loads, in most cases a shear-flow, from the rib into the panel, where this load is distributed between both faces. Fig. 4 shows a









joint which theoretically would meet these requirements. The corrugation transfers the rib loads into the outer face of the panel and also makes a link between the honeycomb cores. This joint is plainly difficult to produce because of the accessibility and welding problems. The solution shown in Fig. 5 would be easy to make but extremely inefficient because of the discontinuity of the faces.

The design in Fig. 6 meets design requirements and is producible. It is best to make the brazed joint without the web, then attach it by subsequent welding. The panel then becomes essentially flat, greatly simplifying the braze fixturing and production sequence. The doubler shown on the drawing may be seamwelded, brazed, or chemically milled as an integral part of the facing. A variation of this design, Fig. 7, shows attachment of a honeycomb sandwich rib to the panel. The U-channel is welded to both pieces to effect the joint with a minimum of manufacturing problems.

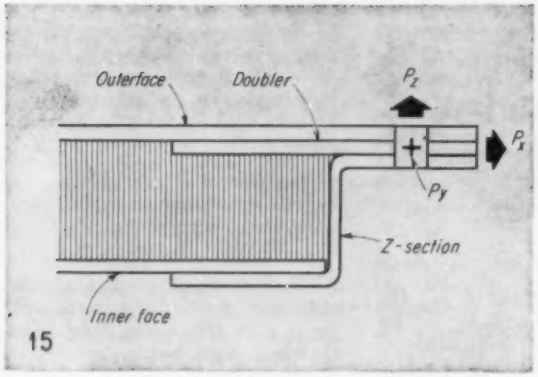
A mechanical joint, if acceptable for the application, is quite simple, as shown in Fig. 8. The rib is directly attached to a densified core insert which provides reinforcement for the countersink and for the bolt-crushing forces. The doubler between rib flange and panel provide better distribution of compression and shear loads.

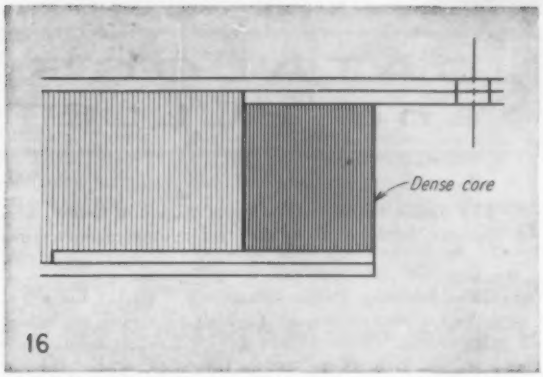
SPAR-PANEL INTERSECTION

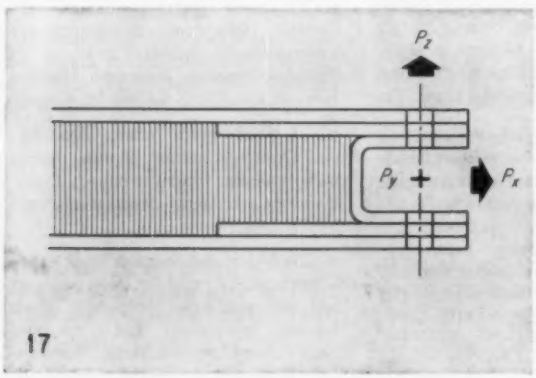
The function of this joint is to transmit shear loads from the panels into the spar and to assist the spar in carrying the bending loads by loading an effective width of the panel in tension or compression. The theoretical joint in Fig. 9 incorporates all necessary elements for correct load transfer. Unfortunately, the unreasonable welding requirements make it almost impossible to produce with current knowledge. The production people would prefer to make the joint as shown in Fig. 10. The limitation of this design is the inability to satisfactorily vary the spar cross-section as loading changes.

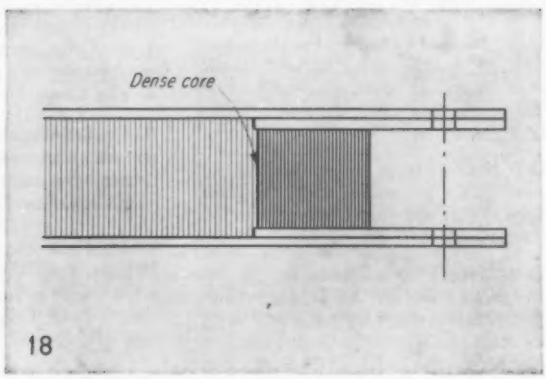
A good design is one that incorporates an independently produced spar to which the panels are welded, Fig. 11. A shear web is introduced between the sandwich and the spar as previously discussed before the elements are welded together. This layout shows a honeycomb sandwich spar web riveted to the spar caps with high-shear rivets. If welding from one side only is necessary a method similar to one previously described (4) is applicable, as shown in Fig. 12. The shear transfer is over the short flange of the edge member and cap flange which must have the rigidity to take the shear load in bending. The cover plate takes forces only in the plane of the outer facing sheet.

Again reverting to a mechanical joint, Fig. 13 is a composite of two types of panel connection to the spar cap. The double joint takes all kinds of loads effectively, while the single joint is able to take shear perpendicular to the panel and loads in the panel of the outer panel facing only. Another interesting variation of a mechanical spar joint enables a simplified approach to joining the









web. Fig. 14 shows a constant-cross-section spar cap incorporated into the basic sandwich. To account for variations in the bending moment, and additional cap strip of varying thickness is placed between the panel and the spar web. The web is then connected to the composite spar cap.

EDGE MEMBER ATTACHMENT

The edge member configuration is important because it fixes the types of loads that can be transferred into the panel. Three loads P_x, P_y, P_z act on a typical Z-section closure, Fig. 15. The load P_z is distributed into the two faces in a manner directly dependant on the stiffness of the Z-section and the core shear modulus in this direction. P_y poses no problem because of the great stiffness of the Z-section in this direction, and it can be assumed that load is transferred equally into both faces. Load P_x is transferred into the vertical web of the Z-section and thus into the core.

Greater producibility control can be obtained by the design in Fig. 16. Some measure of control over P_z distribution into the two faces is possible with more efficiency than an equivalent-weight Z-section joint permits. Load P_y no longer can be assumed to transfer equally into both facings, but favors the outer facing in proportion to the core shear modulus in that direction. Transfer of P_z now occurs along an undesirable path, placing the core-doubler brazed bond in tension. In addition to the marginality of having a brazed joint in tension, the fatigue characteristics make a joint loaded in this manner exceedingly poor. Obviously, P_z acting in the opposite direction presents a much superior condition.

Fig. 17 shows a typical U-channel joint better able to transfer the loads P_x, P_y, and P_z. As a symmetrical attachment, the edge member may be assumed to introduce P_x and P_y equally to the facings without regard to channel stiffness. The U-channel provides a shear web for introducing P_z to the core, but otherwise serves little useful purpose. The major problem in making such a joint—the extremely close tolerances imposed on the formed sheet-metal U-channel—is eliminated by substitution of dense core for the channel in the doubler area as shown in Fig. 18. The shear transfer of load P_z is much more favorable than with the Z-section because the dense core-doubler bond can always be placed in compression to introduce this load.

Problems in the field of brazed sandwich joining have been in the allied area of welding. This is responsible for a temporary regression to less desirable brazed joints by designers whenever possible.

REFERENCE:

Optimum Joint Design for High-temperature Honeycomb Panels by Frank J. Filippi, Project Engineer and Boris Levenetz, Section Chief, Primary Design, Solar Aircraft Co, San Diego, Calif. Paper presented at SAE National Aeronautic Meeting, Oct '59, Los Angeles, California. Paper No. 99-U.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(G-1) **Zinc Soldering Process**—Brochure, 4 pp. Process joins aluminum to itself and other metals. Method used in refrigeration, air conditioning, automotive, electrical industries. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh.

(G-2) **Quick Operating Fasteners**—Brochure, 8 pp. Describes latches, clamps, other fasteners enabling quick access. Camloc Fastener Corp, 22 Spring Valley Rd, Paramus, NJ.

(G-3) **Nuts**—Catalog, 16 pp. Describes all-metal lock, projection weld, standard, clinch, other type nuts. Grip Nut Co, S Whitley, Ind.

(G-4) **Blind Rivets**—Brochure, 4 pp. Gives applications and dimensions of hand-hammer-driven rivets for metal and wood. Star Expansion Industries Corp, Mountainville, NY.

(G-5) **Fasteners**—Catalog, 24 pp. Contains tables of sizes and strengths of blind rivets, blind bolts, pins and stumps—all using unthreaded holes. Huck Mfg Co, 2480 Bellevue Ave, Detroit 7.

(G-6) **Retaining Rings**—Catalog, 15 pp. Tables give ring, groove, housing dimensions and loading factors. Dispenser and application tools also shown. Industrial Retaining Ring Co, 57 Cordier St, Irvington, NJ.

(G-7) **Setscrews**—Catalog, 12 pp. Lists lengths, thread sizes, points, materials and prices. George W Moore, Inc, 100 Beaver St, Waltham, Mass.

(G-8) **Hexagon Nuts**—Brochure, 8 pp. Gives dimensions of such types as jam, castle, lock, slotted and high nuts. National Machine Products Co, 44225 Utica Rd, Utica, Mich.

(G-9) **Stud Welding System**—Catalog, 6 pp. Describes portable, bench and custom built units for welding studs to thin materials. Omark Industries, Inc, 9701 S E McLoughlin Blvd, Portland 22, Ore.

(G-10) **Locknuts and Fasteners**—Catalog. Gives dimensions, load ratings and uses of locknuts, self-threading nuts and push-on fasteners. Shows how to assemble. The Palnut Co, 65-AL Glen Rd, Mountainside, NJ.

(G-11) **Lock Nuts**—Bulletin, 4 pp. Describes self-locking, self-clinching nut for sheet metal. Installation forces tabulated. Penn Engineering & Mfg Corp, Box 311, Doylestown, Pa.

(G-12) **Projection Weld Nuts**—Bulletin, 4 pp. Gives dimensions of steel or stainless steel nut with pilot. Penn Engineering & Mfg Corp, Box 311, Doylestown, Pa.

(G-13) **Self-clinching Nuts**—Bulletin, 12 pp. Describes nuts for sheet metal which cannot be threaded. Penn Engineering & Mfg Corp, Box 311, Doylestown, Pa.

(G-14) **Flush Self-clinching Fasteners**—Bulletin, 4 pp. Presents a captive stud and a nut which is flush on both sides of the sheet. Penn Engineering & Mfg Corp, Box 311, Doylestown, Pa.

(G-15) **Retaining Rings**—Catalog, 24 pp. Shows strengths, shapes, uses and methods of assembly. Truarc Retaining Rings Div, Waldes Kohinoor, Inc, 47-16 Austel Pl, L I City, NY.

(G-16) **Retaining Ring Assembly Tools**—Catalog, 16 pp. Describes tools, fixtures and dispensers for manual assembly; machine driven grooving tool. Discusses groove design. Truarc Retaining Rings Div, Waldes Kohinoor, Inc, 47-16 Austel Pl, L I City, NY.

(G-17) **Lock and Quick-acting Fasteners**—Catalog and bulletin, 16 pp. Lock fastener is used to secure aircraft fuel cells without piercing cell wall. Quick-acting fastener is for access door applications. Truarc Retaining Rings Div, Waldes Kohinoor, Inc, 47-16 Austel Pl, L I City, NY.

(G-18) **Automatic Riveting Machines**—Catalog, 24 pp. Shows machines ranging from single-head, manual types to multi-head automatic designs. Includes selector chart for matching requirements with machine model. Tubular Rivet & Stud Co, Quincy 70, Mass.

(G-19) **Threaded Tubular Rivet**—Catalog, 8 pp. Gives dimensions, styles and applications. Includes automatic setting machines. Tubular Rivet & Stud Co, Quincy 70, Mass.

(G-20) **Rivets**—Catalog, 8 pp. Lists materials and dimensions for semi-tubular, split and outside pronged rivets plus rivet caps. Includes stainless steel semi-tubular rivets. Tubular Rivet & Stud Co, Quincy 70, Mass.

(G-21) **Soldering**—Three bulletins, 6 pp. Presents composition, properties, uses of solder, flux, solder preforms. Alpha Metals, Inc, 56E Water St, Jersey City 4, NJ.

(G-22) **Soldering**—Brochure, 4 pp. Charts and curves give solder strength, melting points, other data. Solder, fluxes, preforms are listed. Alpha Metals, Inc, 56 Water St, Jersey City, NJ.

(G-23) **Screw Fasteners**—Catalog, 8 pp. Contains tables of specifications of screws, lockwashers for industrial fastening. Also electrical terminals. American Machine & Foundry Co, 228 N LaSalle St, Chicago 1.

(G-24) **Stick Form Screws**—Brochure, 4 pp. Describes method of using screws in stick form for rapid driving. Includes dimensions and sizes. American Screw Co, Willimantic, Conn.

(G-25) **Nylon and Stainless Steel Fasteners**—Brochure, 19 pp. Lists alloy composition and uses plus nylon properties. Explains fastener terminology and lists product range. Anti-Corrosive Metal Products Co, Inc, Castleton-on-Hudson, NY.

(G-26) **Epoxy Adhesives**—Brochure, 16 pp. Gives properties of epoxy resins for bonding, casting, coating. Armstrong Products Co, Box 1-PE, Warsaw, Ind.

(G-27) **Clamps**—Catalog, 16 pp. Provides dimensions of clamps for lids, cabinets, equipment hold down, panels and similar uses. The Bassick Co, 3045 Fairfield Ave, Bridgeport, Conn.

(G-28) **Fasteners**—Catalog, 16 pp. Lists sizes of helical spring washers, railroad and pole line spring washers, preassembled nuts and spring washers, retaining rings, and self-tapping, self-drilling screws plus others. Baton Mfg Co, Reliance Div, Charles Ave, Massillon, Ohio.

(G-29) **Wire Rope and Fittings**—Catalog, 24 pp. Shows assemblies and fittings including aircraft quality and nylon coated cables for controls. Gives strengths and dimensions. Bergen Wire Rope Co, Gregg St, Lodi, NJ.

(G-30) **Fasteners**—Bulletin, 4 pp. Describes processes for making such fasteners as screws, bolts, rods, pins. Bethlehem Steel Co, Bethlehem, Pa.

(G-31) **Self-locking Nuts**—Catalog, 64 pp. Presents charts, dimensioned drawings of fixed anchor, floating anchor, hexagon and gang channel types. Boots Aircraft Nut Corp, Newtown Tpk, Norwalk, Conn.

(G-32) Inserts and Tapped Holes—Brochure, 8 pp. Provides information on inserts to provide screw threads and for thinner materials, tapped holes. Includes tables of sizes. Boots Corp, Newton Tpk, Norwalk, Conn.

(G-33) Blind Rivets—Catalog, 8 pp. Shows sizes and how to use countersunk and brazier head explosive rivets of aluminum and brass. The Bowman Products Co, 850 E 72 St, Cleveland 3.

(G-34) Transistor Retainers—Bulletin, 6 pp. Presents selection guide, matching tables for beryllium copper heat dissipating clips and retainers. H Braun Tool & Instrument Co, Inc, 140 Fifth Ave, Hawthorne, NJ.

(G-35) Fuse Clips—Bulletin, 4 pp. Gives service ratings and dimension for clips accommodating NEC and SAE standard fuses. H Braun Tool & Instrument Co, Inc, 140 Fifth Ave, Hawthorne, NJ.

(G-36) Socket Screws—Brochure, 4 pp. Gives dimensions and strengths of miniature flat, button head socket screws. The Bristol Co, Waterbury 20, Conn.

(G-37) Socket Screws—Brochure, 6 pp. Gives dimensions and standards for socket head cap screws. The Bristol Co, Waterbury 20, Conn.

(G-38) Rivets—Catalog, 16 pp. Provides tables of data on tubular and split rivets for automatic setting. Also shows automatic rivet setting machines. Chicago Rivet & Machine Co, 950 S 25 Ave, Bellwood, Ill.

(G-39) Screws and Bolts—Catalog, 150 pp. Gives dimensions, materials, thread data on socket head screws, cap screws, hexagon and square head bolts, lock screws and bolts. Includes thread standards and torque tables. The Cleveland Cap Screw Co, 4444 Lee Rd, Cleveland 28.

(G-40) Removable Fasteners—Brochure, 6 pp. Shows types for fastening detachable panels, covers, housings. Includes design for supersonic aircraft conditions. Dzus Fastener Co, Inc, 125 Union St, W Islip, NY.

(G-41) Adhesive—Brochure, 44 pp. Describes applications, properties, instructions for use of an industrial adhesive. Eastman Chemical Products, Inc, Kingsport, Tenn.

(G-42) Nuts—Catalog, 20 pp. Lists dimensions of turned aluminum and brass nuts. Also lists thread gages and taps on hand. Fischer Special Mfg Co, 446 Morgan St, Cincinnati 6.

(G-43) Washers and Stampings—Catalog, 38 pp. List sizes of flat and formed washers of metallic and nonmetallic materials. Offers light metal stamping service. Freeway Washer & Stamping Co, Box 1756, Cleveland.

(G-44) Keys, Pins, Bushes—Catalog, 36 pp. Lists dimensions and prices of machine and Woodruff keys; taper, dowel, groove and tension pins; describes tension bushes. John Gillen Co, 2540 S 50 Ave, Cicero, Ill.

(G-45) Zinc and Nylon Fasteners—Catalog, 10 pp. Gives materials properties, dimensions of die cast zinc and molded nylon nuts, screws and others. Gries Reproducer Corp, 159 Beechwood Ave, New Rochelle, NY.

(G-46) Pins and Drive Studs—Catalog, 28 pp. Gives sizes and information on how to design for and use grooved pin and stud fasteners. Groov-Pin Corp, 1125 Hendricks Causeway, Ridgefield, NJ.

(G-47) Self-tapping Inserts—Catalog, 12 pp. Gives sizes, strengths and guides on how to design for use in metals, plastics and wood. Groov-Pin Corp, 1125 Hendricks Causeway, Ridgefield, NJ.

(G-48) Lacing Tapes—Catalog, 16 pp. Gives strengths, temperature range of fiber glass tapes and synthetic fiber tapes for harnessing. Gudebrod Bros Silk Co, Inc, 225 W 34 St, NYC 1.

(G-49) Taps—Catalog, 28 pp. Provides explanations and tables for making tap selections. Includes price lists for taps and gages. The Hanson-Whitney Co, 169 Bartholomew Ave, Hartford 2, Conn.

(G-50) Hose Clamps—Catalog, 4 pp. Gives dimensions for stainless steel and galvanized hose and plastic pipe clamps. Ideal Corp, 435 Liberty Ave, Brooklyn 7, NY.

(G-51) Quick Operating Fastener—Catalog, 24 pp. Lists quarter turn fasteners for access panels and similar uses. Types for light to extreme loads. Fastex Div of Ill Tool Works, 195 Algonquin Rd, Des Plaines, Ill.

(G-52) Plastic Blind Nuts—Catalog, 8 pp. Nylon nut snaps into hole from front. Also acts as insulator. Fastex Div of Ill Tool Works, 195 Algonquin Rd, Des Plaines, Ill.

(G-53) Shaft Retention Fastener—Catalog, 8 pp. Lists snap-on spring nuts, plastic rings, c-ring washers. Fastex Div of Ill Tool Works, 195 Algonquin Rd, Des Plaines, Ill.

(G-54) Plastic Blind Rivets—Brochure, 4 pp. Colors can be matched with rivets in four head styles and over six thermoplastics. Fastex Div of Ill Tool Works, 195 Algonquin Rd, Des Plaines, Ill.

(G-55) Plastic Plugs—Brochure, 4 pp. Gives dimensions of plugs used as glides, bumpers, feet. Fastex Div of Illinois Tool Works, 195 Algonquin Rd, Des Plaines, Ill.

(G-56) Self-locking Nuts—Catalog, 118 pp. Provides dimensioned drawings, material, finish, other specifications for many all-metal nut configurations and washers suitable for aircraft applications. Includes miniature and electronics types. Kaynar Mfg Co, Inc, Box 2001, Terminal Annex, Los Angeles 54.

(G-57) Threaded Inserts—Brochure, 4 pp. Gives dimensions and installation method. Insert for ductile materials also serves as nut. The Lamson & Sessions Co, 5000 Tiedeman Rd, Cleveland.

(G-58) Self Locking Thread Form—Brochure 4 pp. Male threaded fastener reforms female threads to provide interference fit. Lock Thread Corp, 2832 E Grand Blvd, Detroit 11.

(G-59) Lockbolt and Lockscrews—Brochure, 6 pp. Explains locking method and physical properties. Long-lok Corp, 2601 Colorado Ave, Santa Monica, Cal.

(G-60) Steel Screws—Catalog, 36 pp. Provides standards, dimensions and mechanical properties. General types shown include socket head, square head and hexagon head. Mac-it Parts Co, E Liberty St, Lancaster, Pa.

(G-61) Alloy Fasteners—Bulletin, 22 pp. Lists bolts, nuts, screws, others by their AN, NAS and MS numbers. Includes chart to match appearance with AN series. Mercury Air Parts Co, Inc, 9310 W Jefferson Blvd, Culver City, Cal.

(G-62) High Temperature Fasteners—Catalog, 12 pp. Aircraft quality fasteners of AMS5735 alloy are designed for 1300F service. Detailed specs shown of seven screws, bolts, others. Mercury Air Parts Co, Inc, 9310 W Jefferson Blvd, Culver City, Cal.

(G-63) Rivets—Catalog, 8 pp. Furnishes tables of dimensions, design and selecton guides. Also rivet setting machines. Milford Rivet & Machine Co, 857 Bridgeport Ave, Milford, Conn.

(G-64) Blind Fastener—Brochure, 4 pp. Presents specifications, installation instructions for a type of threaded blind fastener. Molly Corp, 230 N Fifth St, Reading, Pa.

(G-65) Sliding Fastener for Panels—Bulletin, 4 pp. Snap-action latch secures removable covers and doors. Gives dimensioned drawings for two different sizes. Monadnock Mills, 1977 First Ave, San Leandro, Cal.

continued

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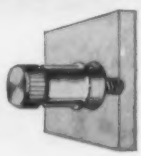
Southco standards provide many benefits at low cost for access through doors, covers, panels and into drawers

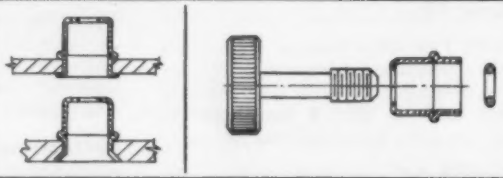
LION ¼ TURN FASTENERS

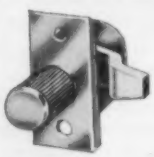
Quick, positive locking, by fractional turn. Tight seal formed by compression of leaf spring. Alignment and stack height not critical. Approved for aircraft use. Rugged. Extra strength provided by swaged nose. Vibration resistant.



RETRACTABLE SCREW FASTENERS

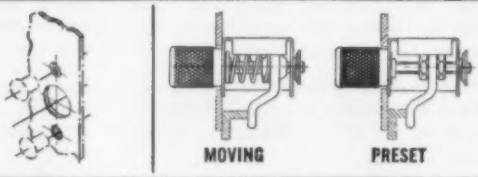
Stand-off thumb screws from stock to eliminate costly, special fasteners. Installed quickly without special tools. Accommodate misalignment. Complete range of standard sizes.





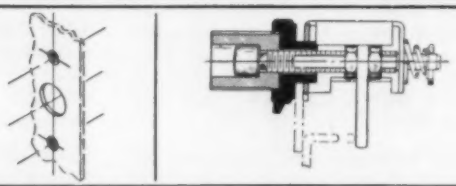
ADJUSTABLE PAWL FASTENERS

Pre-assembled, quickly installed. Accommodate variations in frame thickness up to ½ inch. One-quarter turn closes, additional turns increase grip pressure. Attractive appearance, long life. Moving or pre-set pawl. Miniature, intermediate and large sizes.



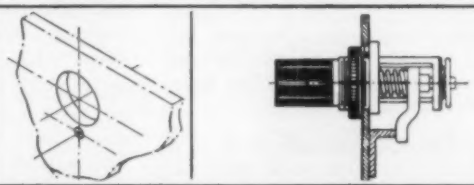
ADJUSTABLE PAWL FASTENER

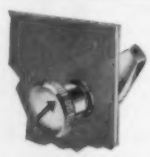
Has twin-knob control. One knob controls pawl, pointer shows pawl position. Other knob controls amount of pressure to seal closure with uniform pre-set compression. Easily installed.



ADJUSTABLE PAWL FASTENER

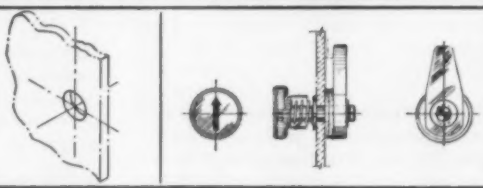
Compact and rugged. Eliminates rivets or bolts to save installation time. Three types cover grip range up to ¾". Supplied either with integral metal and plastic knob, plastic knob or for your knob.





ARROWHEAD DOOR LATCH

Requires only one hole to install. Operates on quarter turn. Holds under spring tension. Arrow shows pawl position; no pawl stops required. Uses minimum inside space.



SOUTHCO FASTENERS
LION

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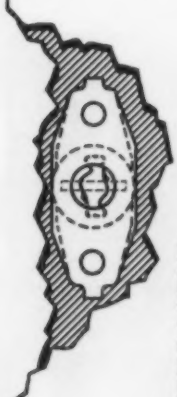
For quick access and closure . . .

LION ¼ TURN OPEN ¼ TURN CLOSED FASTENERS



NO. 5 STUD

RETAINER

RECEPTACLE

Hinged and completely removable panels are secured reliably by unique Lion Fasteners which are opened or closed by a quick ¼ turn. These mil spec (MIL-F 5591A-ASG) fasteners have a high strength to weight ratio, lock smoothly with a positive grip, withstand vibration.

ALIGNMENT NOT CRITICAL

Both stud and receptacle "float" to accommodate misalignment. The hole, which retains the stud, is twice as large as the stud cross-section. This permits a float of .070 in all directions. The leaf spring receptacle also floats to accommodate stud positions.

WIDE VARIATIONS IN STACK HEIGHT

Total sheet thickness may vary as much as +.035 or −.015 without affecting operation. A Lion stud, specified for .160 total thickness, for example, will accommodate any stack height between .195 and .145.

SWAGED-NOSE STUD

Extra strength and smooth operation are made possible by the swaged-nose design. All the metal in the stud goes to work. There are no thin crosspins, holes or milled slots to weaken the cross-section. Case hardening is further assurance of long, trouble-free service.

WIDE VARIETY

Lion Fasteners are available in 3 sizes —No. 5, No. 2, and Miniature. An assortment of head styles is supplied —oval, flush, wing, ring, notched or knurled—according to individual requirements.

FREE!
FASTENER HANDBOOK

Send for your free copy of Southco Fastener Handbook No. 9. Gives complete engineering data on Lion Fasteners and other special fasteners. Write to Southco Division, South Chester Corporation, 260 Industrial Highway, Lester, Pennsylvania.

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LION *Aviation* FASTENERS

one of the SOUTHCO LION FASTENERS

HANDY ALLOY DATA SHEET

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HANDY & HARMAN SILVER BRAZING ALLOYS

NAME	COMPOSITION PERCENTAGE Ag	Cu	Zn	Other	MELTING POINT °F	°C	FLOW POINT °F	°C	TROY OUNCES PER CU. IN.
EASY-FLO	50	15½	16½	(18 Cd)	1160	625	1175	635	5.0
EASY-FLO 3	50	15½	15½	(16 Cd-3 Ni)	1170	630	1270	690	5.0
EASY-FLO 45	45	15	16	(24 Cc)	1125	605	1145	620	4.9
EASY-FLO 35	35	26	21	(18 Cd)	1125	605	1295	700	4.9
SIL-FOS	15	80		(5 P)	1185	640	1300	705	4.5
SIL-FOS 5	5	88¾		(6¼ P)	1185	640	1300	705	4.4
TEC*	5			(95 Cd)	640	340	740	395	4.6
TEC-Z*	5		16.6	(78.4 Cd)	480	250	600	315	4.5
BRAZE 071 (SN #7)†	7	85		(8 Sn)	1225	665	1805	985	4.8
" TL	9	53	38		1410	765	1565	850	4.5
" ATT	20	45	30	(5 Cd)	1140	615	1500	815	4.6
" 202 (AT SPEC)†	20	45	35		1315	715	1500	815	4.7
" NE	25	52½	22½		1250	675	1575	855	4.7
" 251 (AE)†	25	57½	17½		1270	690	1625	885	4.7
" NT	30	38	32		1250	675	1410	765	4.7
" DT	40	36	24		1235	670	1415	770	4.8
" SS	40	30	28	(2 Ni)	1220	660	1435	780	4.8
" 404 (SS-5)†	40	30	25	(5 Ni)	1220	660	1580	860	4.7
" DE	45	30	25		1225	665	1370	745	4.8
" ETX	50	34	16		1250	675	1425	775	5.0
" 541 (4772)†	54	40	5	(1 Ni)	1340	725	1575	855	5.1
" 560 (ER)†	56	22	17	(5 Sn)	1145	620	1205	650	5.0
" 580 (EB)†	57½	32½		(7 Sn-3 Mn)	1120	605	1345	730	5.1
" RT	60	25	15		1245	675	1325	720	5.0
" 603 (RT-SN)†	60	30		(10 Sn)	1115	600	1325	720	5.2
" 630 (RSNI)†	63	28½		(6 Sn-2½ Ni)	1275	690	1475	800	5.1
" EASY	65	20	15		1240	670	1325	720	5.1
" 655 (RE-MN)†	65	28		(5 Mn-2 Ni)	1385	750	1560	850	5.2
" MEDIUM	70	20	10		1275	690	1360	740	5.1
" BT	72	28			1435	780	1435	780	5.2
" HARD	75	22	3		1365	740	1450	790	5.3
" 752 (TR #1)†	75		25		1300	705	1330	720	5.1
" IT	80	16	4		1340	725	1490	810	5.3
" 852 (85 Ag-15 Mn)†	85			(15 Mn)	1760	960	1780	970	5.1
PREMABRAZE 610	61	24		(15 In)	1155	625	1305	705	5.0

*A Solder – Not a Brazing Alloy. †Former Names

Space does not permit listing the many special alloys, formulated for a particular or unique application. Handy & Harman Brazing Engineers and Technical Service are always ready to work closely with you on metal joining problems and methods.

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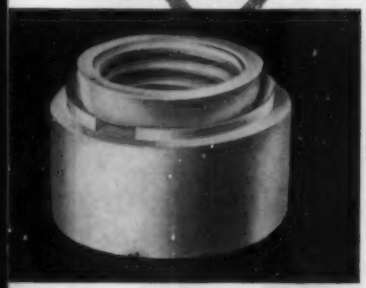
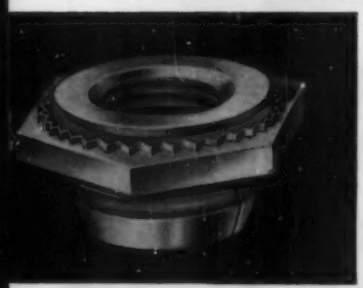
PEM CAPTIVE THREADS for Production Fastening...

THE ORIGINAL SELF-CLINCHING FASTENER



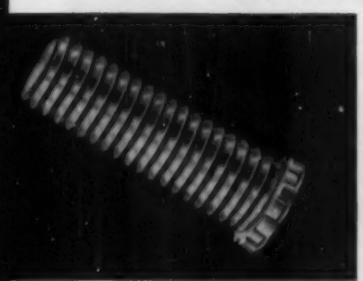
Made in steel, stainless steel, aluminum and Monel. Positively locked into prepared holes by any standard squeezing tool. For metal thicknesses down to .032". Sizes from No. 0 to ¾". Bulletin CL.

SELF-CLINCHING, SELF-LOCKING NUT



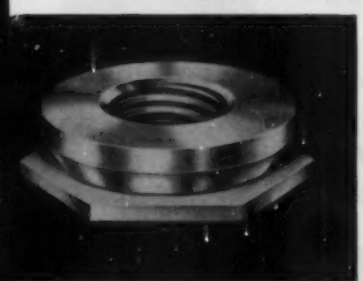
All metal (steel, stainless steel or aluminum) combines 2 functions in single light-weight, low-cost unit for sheet metal fastening. Suitable for installation in sheet thicknesses from .040" and up. Sizes from No. 4 to 10. Bulletin SL.

SELF-CLINCHING CAPTIVE STUD



Steel and stainless steel, designed for quick, easy flush-head installation in panels of cold-rolled steel, brass, copper, aluminum alloys and similar materials. Sizes No. 4 to 5/16". Lengths from ¼" to 1½". Bulletin FH.

SELF-CLINCHING FLUSH FASTENER

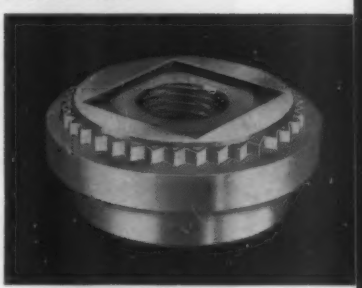


One-piece, stainless steel threaded insert installs in sheet thicknesses from .061" and up with flush mounting area on both sides of sheet. Suitable for materials with Rockwell Hardness of B-70 and less. Sizes No. 2 to ¼". Bulletin FH.

SELF-LOCATING WELD FASTENER

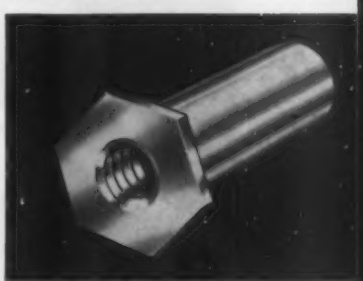
Steel and non-magnetic stainless steel. Nut is projection welded to part with extended shank protecting threads from weld splatter and serving as pilot in assembly. No. 2 to ¼". Bulletin WN.

SELF-CLINCHING FLOATING NUT



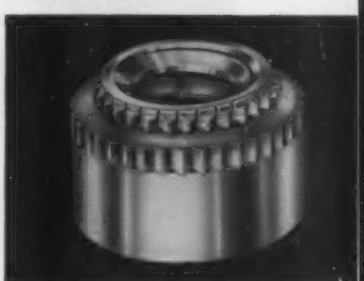
Carbon steel and stainless steel. Provides rapidly assembled nut anchor in sheet metal and compensates for slight errors (up to 1/32") in alignment of mating holes. Sizes No. 2 to ¼". Suitable for sheet thicknesses from .040" up. Types AS and AC.

SELF-CLINCHING STAND-OFFS



Made in both blind and threaded-through types in steel, aluminum and stainless steel. Sizes No. 4 and No. 6. Overall lengths from 1/8" to 1 1/16". Suitable for use in sheet thicknesses from .040" and up. Bulletin SO.

SELF-CLINCHING SPLINE FASTENER



For hard metals and brittle materials — magnesium, glass laminates, epoxies, etc. Made in steel and stainless steel. Sizes No. 2 to 3/8". Type KF.

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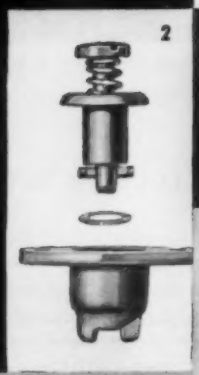

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9. 4002 Series Quarter-Turn
10. SPF (Stressed Panel Fastener)

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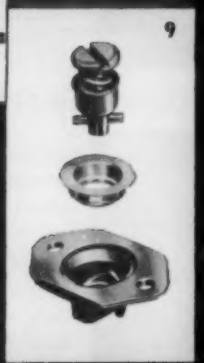

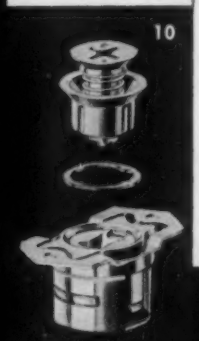

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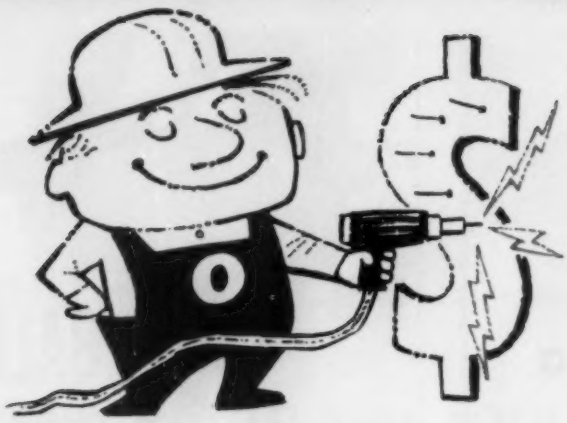

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"FASTEN ONTO SOMETHING GOOD"

KNOW THE MAN WHO CAN SHOW YOU HOW

Specifically, for multiple fastening to all kinds of metal . . . thick or thin . . . for light load or heavy . . . with equipment you take to the job (as in building and construction), or work you take to the fastening machine (as in product manufacture and assembly) . . . it pays to know the man from OMARK.

He not only offers you a system of burn-and-distortion-free stud welding which solves your metal fastening problems. He also brings you dependable on-the-job counsel, and an engineering service to help you specify exactly the right studs and equipment you need.

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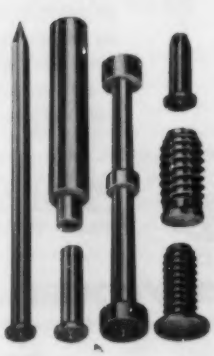

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The Automatic Chobert High Speed Riveting Gun holds a mandrel of up to 65 rivets, each automatically held ready for installation as fast as the operator can position the portable gun. Hand placing and bucking of rivets is eliminated . . . no finishing is required. Chobert simplifies blind or open fastening on vertical, horizontal or overhead surfaces, even areas normally considered inaccessible.

EVERY RIVET UNIFORMLY SET

Each rivet expands evenly, assuring uniformity of strength and vibration resistance, without distortion or marring sheet metal. Chobert aluminum or mild steel rivets are available in diameters from 3/32" to 1/4".

The Chobert System is successfully used by leading manufacturers of appliances, industrial equipment, electronic components, aircraft, missiles and other sheet metal fastening operations.

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360 CIRCLE 360 ON READER SERVICE CARD

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PINS

FAST . . . SAFE . . . DEPENDABLE

Available in both single acting and double acting styles.

The ideal fastener for applications where parts or assemblies are frequently assembled or disassembled for service or replacement. Also BALL-LOK PINS are widely used as a safety fastener to prevent accidental or premature release of movable assemblies.

For every design requirement where a pin fastener must be easy to insert . . . quick to withdraw, yet provide positive safety BALL-LOK single acting pins serve best. Five head styles adapt to all design requirements. Pins range from 3/16" (#10) to 1" diameter.

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Double acting BALL-LOK Quick Release Pins combine rugged strength with instant insertion, easy withdrawal and self safetying. In cases where ordinary fasteners may bind in misaligned holes or under heavy loads the added "drive-in" "drive-out" spindle permits forcible release of the pin. Double acting pins are available in "Ring," "T" and "L" head styles. Use the experienced technical knowledge of our engineering staff to help solve your quick release fastener problems.

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AVDEL, Inc. is the new corporate name for the combined facilities of Aviation Developments, Inc. and D. W. Price Corp., leading manufacturers of quick release pins.

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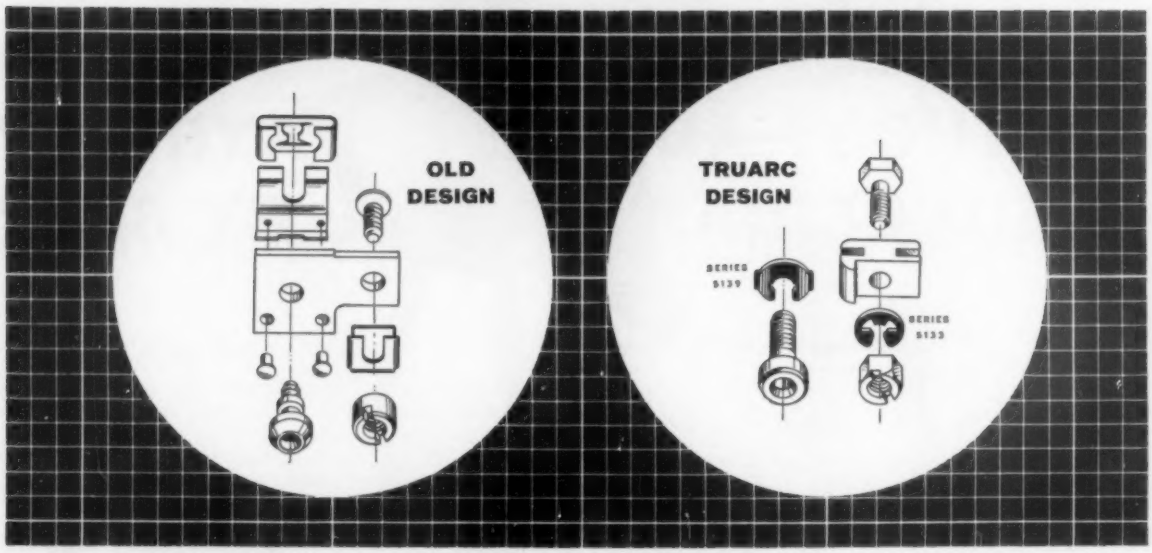
CIRCLE 656 ON READER SERVICE CARD

How Truarc rings simplified design and saved $60 per 1000 units



Look behind this big saving in parts on the auto contact points made by Shurhit Products Inc., Waukegan, Illinois. One Truarc Ring replaced an expensive special purpose fastener. Another eliminated a clip and retaining plate which were 4 times more expensive and difficult to assemble. A third replaced a special purpose nut.

Equally important, besides simplifying and improving design, Shurhit reduced the over-all size of its auto points by ¼" and reduced assembly time by 50%. *Savings: $60 per 1000 units.* Let Truarc Rings help cut your basic manufacturing cost by simplifying design and making assembly faster and easier. Rings often contribute highly saleable compactness as well!

WHY TRUARC RINGS BELONG ON YOUR PRODUCT

They offer a simple and effective way to locate, retain or lock components in place. They fit into grooves inside bores and housings. They work as effectively on shafts or studs (some without grooves).

More than a fastener! Truarc Rings act as a component by replacing machined shoulders, threaded fasteners, rivets and other fastening devices. What's more, they often eliminate threading, tapping, drilling and other machining operations.

Available in 50 types (some with up to 98 sizes), in 6 metals, and 13 finishes—Truarc Retaining Rings can be conveniently ordered from more than 100 stocking points throughout the U. S. A. and Canada.

Read about the impact of Truarc Rings on more than 70 different designs (your product type may be among them) in our Catalog RR 10-58. For *immediate* action call your nearest **Authorized Truarc Distributor.** Look under "Rings, Retaining" in the Classified Telephone Directory. O.1

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RETAINING RINGS

WALDES KOHINOOR, INC.,
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9 OUT OF 10 PRODUCTS CAN BE IMPROVED WITH TRUARC RETAINING RINGS

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CIRCLE 361 ON READER SERVICE CARD 361

3-Point Support Helps You Design for Simpler, Lower-Cost Assembly

RIVETS

TRS offers you an unsurpassed choice of tubular rivets, quickly available to handle almost any fastening problem. Also, the Perma-Nut, a versatile combination of rivet and nut. You can't beat rivets for low in-place cost . . . or TRS rivets for uniform, trouble-free performance.

RIVETING MACHINES

TRS has the machines, no matter what the type or capacity, to help you obtain the full money-saving advantages of automatic riveting as an assembly method. With TRS riveters, impossible-to-rivet jobs often become practicable . . . standard jobs always become more efficient.

PAR PROCESS

A TRS man puts the PAR PROCESS to work for you through a planned check of your assembly operations. Aimed at improving efficiency by eliminating, simplifying, speeding up steps, this unique TRS approach makes riveting practically a new method of assembly.

USE TRS SUPPORT early in your planning. Invite a TRS Engineer to demonstrate the unequalled combination of fasteners, machines and know-how that has uncovered important economies for hundreds of assemblers.

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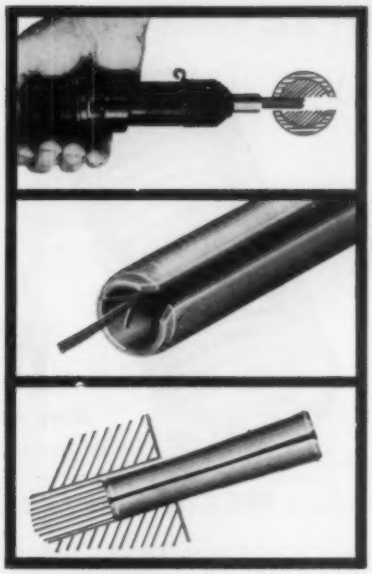
If it's a Tubular Rivet TRS makes it . . . and Better

Rollpin won't mushroom or telescope

There are no installation or removal problems with Rollpins. Because of their column strength they can be readily driven with a hammer, removed with a punch without bending or collapsing. Of course production line tooling such as an arbor press, a pneumatic hammer . . . even a hand riveter . . . is ideal for Rollpin insertion.

Rollpin won't damage or enlarge hole

With smoothly chamfered ends providing an easy lead-in, Rollpin is compressed into complete conformity with the shape of the hole. The exclusive, v-shaped, coped corner design eliminates possibility of damage to the hole walls. They prevent any possible scoring action as the pin is driven and insures uniform insertion and removal characteristics. The benefit to you: the same pin can be reused in the same hole.



ONLY ROLLPIN OVERCOMES ALL THESE FASTENING PROBLEMS!

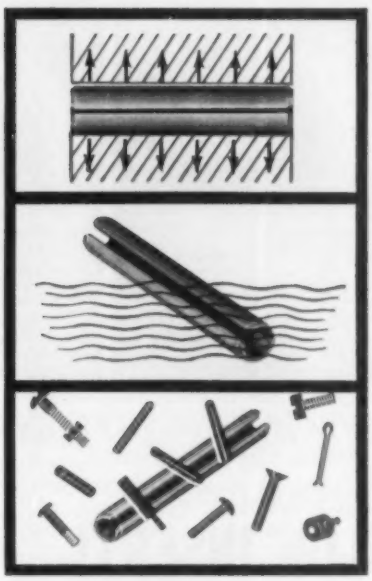
Rollpin exerts EVEN pressure

In some fasteners, only a portion of the fastener shaft does the actual holding. Rollpin, however, exerts a uniform pressure around the entire inside surface of the hole—giving you maximum holding power and superior resistance to vibration.

Split tubular construction assures uniformity of heat treatment that is difficult to obtain with spiral types of pins; there is an even plating "throw" inside the pin as well as outside for superior corrosion protection.

ONE TYPE of Rollpin does EVERY TYPE of job

Versatile Rollpins will replace at least 12 different types of fasteners. Every Rollpin can be hopper-fed, can be installed with a single operation. They are available, from stock, in a wide range of lengths and in diameters from 1/16" to 1/2". Manufactured from carbon or corrosion resistant steels and beryllium copper.



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ELASTIC STOP NUT CORPORATION OF AMERICA

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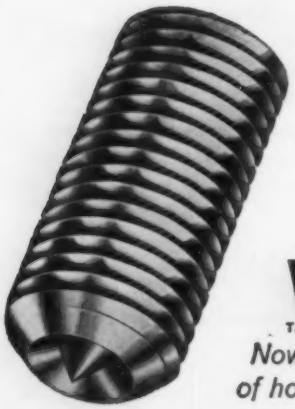

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The New PARKER-KALON **W-POINT** Socket Set Screw

T.M. U.S. PATENT NO. 2,907,245

Now you can get the highest degree of holding power ever attained!

30% more back-out torque 50% more resistance to vibration 50% more resistance to rotary slippage

Like many important advances in technology, the Parker-Kalon W-Point concept is simple and straightforward. In use, its superior performance and holding power will be demonstrated to your own satisfaction. Available from P-K distributors at no increase in cost.

A COMPLETE LINE OF SOCKET SCREWS TO MEET EVERY REQUIREMENT!

SOCKET HEAD CAP SCREWS

Heads are of uniform diameter. Threads Class 3A tolerance. Available in standard sizes from #0 to 1½" diameter in alloy steel and from #0 to ½" diameter in stainless steel. Available in 1938 and new 1960 "Pre-Lode" Series.

SOCKET SET SCREWS

Precision Class 3A threads, standard in Cup Point from #0 to 1" and in Flat, Oval, Cone and Half-Dog Points from #4 to ⅜". Cup Point also available in stainless steel.

SHOULDER SCREWS

Threads Class 3A tolerance. Heads are concentric with body for uniform, accurate assembly. Available in standard sizes from ¼" to ¾" diameter.

FLAT HEAD SOCKET CAP SCREWS

Seats flush when countersunk. Heads have uniform 82° angle. Threads Class 3A tolerance. Special alloy steel, heat treated. Available in standard sizes from #4 to ¾".

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Heat treated alloy steel. Accurate hex sockets make for non-slip driving, prevent mutilated heads. Threads Class 3A tolerance. Standard sizes from #4 to ⅜".

SOCKET SEMS

P-K is the only fastener manufacturer to provide socket Sems, to meet your needs for precision-made socket head cap screws with split ring washers.

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Made of special anafysis alloy steel, scientifically engineered. Heat treated for optimum physical characteristics. Made to close tolerances.

DOWEL PINS

SOCKET PIPE PLUGS

Now you can get all of these famous P-K® quality socket screws with or without

the vibration-resistant **LONG-LOK® INSERT!**

Look at that groove! It's P-K's secret weapon against vibration. Filled with Polycap nylon-type polymer, it solves a thousand and one problems where vibration is present . . . where adjustment is required . . . where reuse is a factor, over a wide temperature range.

- *Provides higher resistance to shock*
- *Higher percentage of reusability*
- *Superior thread engagement and locking force*
- *Eliminates need for lock washers, safety wires*
- *The Long-Lok insert is available on P-K Socket Head Cap Screws, Set Screws, Flat Heads, Button Heads, Shoulder Screws and Pipe Plugs.*

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FASTENERS

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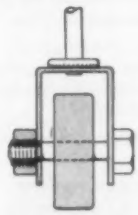
THE LIQUID LOCK FOR METAL PARTS

. . . improves fastener reliability and reduces costs!

LOCTITE sealant makes ordinary fasteners into lock fasteners at savings of 40%-70%. Locking action extends over the entire engaged area providing unequalled resistance to vibration . . . ends breakdowns due to loosening of fasteners. A single drop of LOCTITE replaces all sizes of lock nuts, lock washers, lock screws, jam nuts, staking and interference threads.

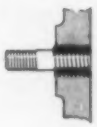
– ELIMINATES LOCK WASHER OR SELF-LOCKING SCREW

Makes ordinary screws into lock screws. Several times the holding power at savings of $20/M.



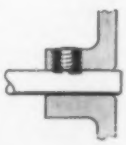
– ELIMINATES SELF-LOCKING NUT OR JAM NUT

Locks non-seated nuts anywhere along the length of thread.



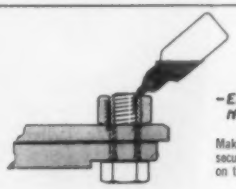
– ELIMINATES INTERFERENCE FIT

Locks studs securely . . . locking action develops after stud is in place . . . allows easy-driving Class 2 threads. End stripped threads, broken studs, damaged castings.



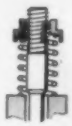
– ELIMINATES DOUBLE SET SCREWS, SELF-LOCKING SET SCREWS, JAM NUTS ON EXTENDED SET SCREWS OR STAKING

LOCTITE-treated set screws cannot vibrate loose . . . end nuisance service calls.



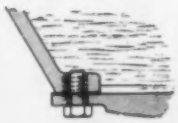
– ELIMINATES SELF-LOCKING NUT OR LOCK WASHER

Makes any nut a lock nut. Saves 40%-70%. Holds securely where lockwashers fail. Does not depend on tightening torque for locking action.



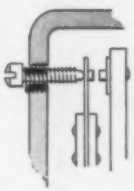
– ELIMINATES SPECIALS OR STAKING

Makes any threaded part self-locking.



– ELIMINATES BLIND HOLE TAPPING, SPECIAL LEAK-PROOF FASTENERS

LOCTITE locks and seals threaded parts against vibration and high-pressure fluids.



– ELIMINATES SELF-LOCKING SCREW OR JAM NUT

Get the right setting the first try . . . no backlash. LOCTITE provides the proper amount of drag to hold adjustment securely. Permits repeated adjustments.

LOCTITE Sealant is easy to apply . . . simple to automate

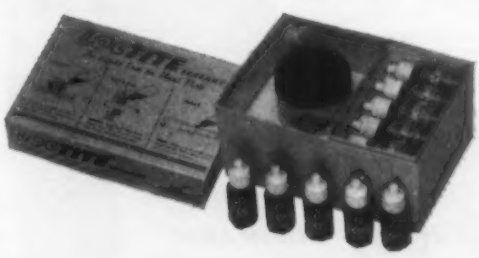
Labor savings are obtained when several days supply of threaded parts are treated by tumbling with LOCTITE Sealant. Treated parts store for days, lock only when assembled. Smaller quantities may be tumbled by hand in polyethylene bags. Parts may be individually treated using applicator nozzle on LOCTITE bottle or by using continuous feed tube. Parts may be treated *after* assembly, LOCTITE wicks into threads by capillary action.

LOCTITE is a thin liquid that hardens into a tough heat and oil-resistant seal when confined between closely fitting metal parts. It requires no heating or mixing . . . does not air dry. LOCTITE comes fully prepared . . . stores for years . . . hardens only when treated parts are assembled. Ten grades provide any desired torque to all sizes and types of fasteners. LOCTITE-treated fasteners may be removed with ordinary tools . . . fasteners may be re-used.

LOCTITE Kit No. 10-10

Contains 10 grades of Loctite sealant specially put up to assist engineers in determining proper grade of Loctite in product development and for general experimental work. By selection of proper grade, the designer can apply a pre-determined amount of locking torque.

Write for literature and free sample capsule.



LOCTITE® SEALANT

AMERICAN SEALANTS COMPANY • 119 WOODBINE ST., HARTFORD 6, CONN.

CIRCLE 365 ON READER SERVICE CARD 365

SPEED PRODUCTION and LOWER COST on your products with this GRIP-NUT family of GRIPCO FASTENERS

GRIPCO LOCK NUT
One piece all metal.

GRIPCO CENTERLOCK NUT
Locking feature in the center for fast feeding. Can be applied from either end.

GRIPCO CLINCH NUT
With or without Gripco lock. For application to metal too thin to thread or for inaccessible assemblies. Hex collar prevents turning when torqueing bolt.

GRIPCO PILOT-PROJECTION WELD NUT
With or without Gripco Lock. Centering collar positions nut and protects threads from weld spatter.

GRIPCO COUNTERSUNK WELD NUT
With or without Gripco Lock. Countersink protects threads from weld spatter.

All types and sizes of Gripco fasteners listed in catalogue are available for immediate delivery.

Qualified fastener engineers are available for consultation on all your assembly problems.

Other Gripco Products:

- BRASS GRIPCO OR CENTERLOCK NUTS.
- MINIATURE WELD AND CLINCH NUTS, WITH OR WITHOUT LOCK.
- GRIPCO AND CENTERLOCK HI NUTS.
- STANDARD SEMI-FINISH FULL AND JAM NUTS.
- STAINLESS STEEL LOCK, WELD AND SEMI-FINISH NUTS.
- COLD FORMED SPECIAL NUTS OR PARTS TO PRINT.

The Nation's Oldest Manufacturer of Lock Nuts

R4 *Send for samples and NEW CATALOG today*

GRIP-NUT COMPANY

102 MAPLE AVE. ★ SOUTH WHITLEY, INDIANA

366 CIRCLE 366 ON READER SERVICE CARD

cut production time and costs with **INDUSTRIAL RETAINING RINGS**

Save material, eliminate costly machining and tooling, speed assembly with precision-made INDUSTRIAL Retaining Rings. They can be re-used over and over again because of their lasting resiliency and sustained circularity.

Internal, external and open types are available for immediate delivery in a wide range of sizes and finishes. Open-type rings are also available stacked for speedier assembly.

Write today for free ring samples and catalog.

IRR *Originators of modern retaining ring dispensing*

INDUSTRIAL RETAINING RING COMPANY

PE-9, 57 Cordier Street • Irvington 11, New Jersey

CIRCLE 657 ON READER SERVICE CARD

USE THE READERS' SERVICE CARD on pages 17 to 22 for:

additional product information

copies of catalogs & bulletins

catalogs and bulletins.....continued

(G-66) **Retainers of Molded Plastic**—Prints, 14 pp. Retainers hold fabrics. Retainers may be decorative or hidden. Prints detail parts and methods of attaching. Monadnock Mills, 1977 First Ave, San Leandro, Cal.

(G-67) **Clip-on Nuts**—Bulletin, 11 pp. Spring clip and nut replaces riveted nutplate. Prints detail different sizes. Monadnock Mills, 1977 First Ave, San Leandro, Cal.

(G-68) **Door-retaining Cable Fasteners**—Bulletin, 23 pp. Quick-acting fasteners allow access doors to hang from cable when door is open. Provides prints of all parts. Monadnock Mills, 1977 First Ave, San Leandro, Cal.

(G-69) **Spring-loaded Latch**—Bulletin, 8 pp. Spring-loading reduces noise from removable panels and doors. Prints show each part. Monadnock Mills, 1977 First Ave, San Leandro, Cal.

(G-70) **Curtain Slides**—Bulletin, 10 pp. Slides are designed for aircraft. Curtains attached by snap fastener or hooks. Includes prints. Monadnock Mills, 1977 First Ave, San Leandro, Cal.

(G-71) **Threaded Panel Fastener**—Brochure, 6 pp. Quadruple threads make screw quick-acting. Sizes for sheet metal from 0.100 to 0.924 in. thick. Monadnock Mills, 1977 First Ave, San Leandro, Cal.

(G-72) **Junction Box Fastener**—Data sheets, 4 pp. Cutaway views, dimensioned drawings and size tables give details on quick-acting door, cover and panel fastener. Monadnock Mills, 1977 First Ave, San Leandro, Cal.

(G-73) **Assembly Fasteners**—Brochure, 8 pp. Provides a general idea of self-retaining fasteners company makes from strip. Most are adapted for high production. Robin Products Co, 27027 Groesbeck Hwy, Warren, Mich.

(G-74) **Weld Fasteners**—Catalog, 50 pp. Lists dimensions for weld nuts, weld screws, special purpose weld parts. Includes welding and electrode data, sample welding setups and uses. The Ohio Nut & Bolt Co, 33 First Ave, Berea, Ohio.

(G-75) **Hot Melt Adhesives**—Catalog, 12 pp. Rolls of adhesive in cord-like form are for paper, leather, fabric and plastics. Also shows machines for applying. United Shoe Machinery Corp, 140 Federal St, Boston 7.

continued

Genuine ALLENS

...first choice of industrial designers for stronger, tighter fastenings!

Here's the way to figure it:

The cost of *genuine* Allen Hex Socket Screws is such a minor fraction of your assembly costs that you'll surely want *your* products to have the many advantages that only *genuine* Allens can give you!

1457 STANDARD ITEMS

ADVANCED DESIGN FEATURES: "Pressur-forming" that preserves the long fibers throughout the length of Allen Hex Socket Screws . . . the deep, full circle bite of Allenpoint Set Screws . . . deep, clean, strong-walled sockets . . . these, and many other advantages that make your product better, are yours *only* with *genuine* Allen Hex Socket Screws and related products.

WRITE FOR . . . Allen "Technical Library" handbooks filled with helpful socket screw data—answers to any questions you may have on specifications and dimensions—special alloys—finishes and surface treatments—strength characteristics, etc. Or ask your industrial distributor for copies.

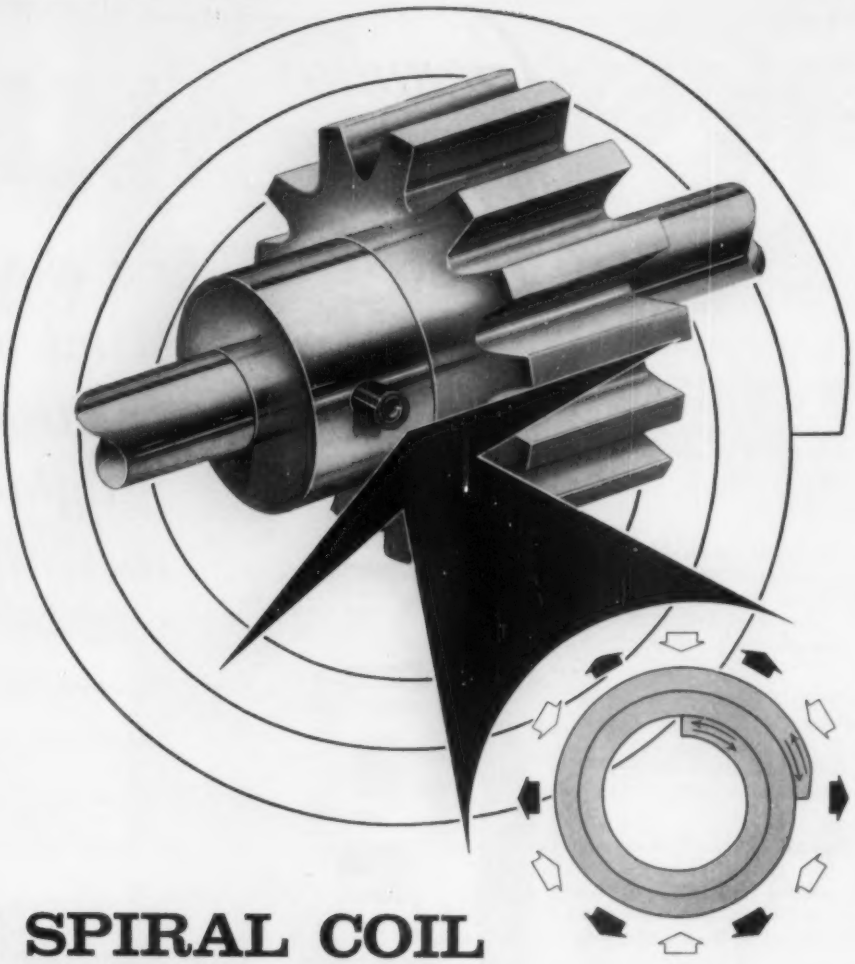
50 ANNIVERSARY YEAR ALLEN HEAD 1910-1960

Genuine Allen products are sold only through leading Industrial Distributors. Your Industrial Distributor will give you practical advice on Allen products and he'll provide samples—and special help from Allen's Engineering Service.

THE ALLEN MANUFACTURING COMPANY, HARTFORD 1, CONNECTICUT

PLANT AT BLOOMFIELD, CONNECTICUT • WAREHOUSES IN CHICAGO AND LOS ANGELES

CIRCLE 367 ON READER SERVICE CARD 367



THE SPIRAL COIL

makes SPIROL a true spring PIN

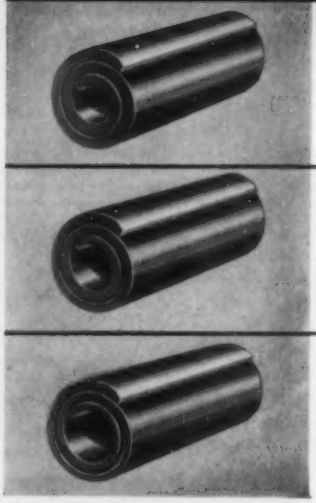
SPIROL PIN is a spirally coiled metal strip that acts like a true spring. When the pin is compressed into a hole, the radial tension is distributed *uniformly* throughout the spiral coils. There is no concentration of stress along a fragile "hinge line". This real coil-spring action permits wider plus-*and*-minus hole tolerances . . . eliminates precision reaming . . . works successfully with *low-cost* non-heat-treated metals. SPIROL's greater resilience increases shear strength, shock and vibration resistance.

FREE! *Write for literature on Spirol Pins.*

®SPIROL *the true spring* **PIN**

C. E. M. COMPANY, INC. • 42 SCHOOL ST.• DANIELSON, CONN.

SPIROL offers the widest range of flexibility, tension, and strength . . .



HEAVY DUTY

For applications where shear and shock loads are extremely severe, Spirol pin's spring action withstands high stress.

MEDIUM DUTY

Flexibility enables medium duty pins to absorb severe vibration. Have adequate shear strength for majority of applications.

LIGHT DUTY

Recommended for use in soft and brittle materials where the allowable bearing loads are low.

ingenuity

research—

development

solves

SPRING

FASTENER

problems

Garrett OF PHILADELPHIA

This is for an engineer . . . who is faced with a fastener problem. Forget your empty drawing board. Let Garrett ingenuity, through its research and development department, solve your spring fastener problem. Garrett spring fasteners may be complex or simple . . . custom or special . . . large or small. Whichever they may be, each has a common quality—the ability to solve your particular fastener problem. Furthermore, this quality can be proved through sample quantities by your own testing facilities.

Of course, Garrett maintains complete stocks and sizes of many variations of flat nuts, "J" nuts, "U"—in both cone and twin-prong impressions — as well as round and rectangular push-on nuts for immediate delivery.

Garrett offers complete facilities, and exercises strict quality control in every manufacturing operation of spring fasteners . . . from stamping to heat treating through plating or finishing, including Garrettizing, our own new mechanical impact method of zinc plating **without** hydrogen embrittlement.

For further information, write GARRETT . . . THE MOST COMPLETELY INTEGRATED PLANT IN THE INDUSTRY.

Garrett SPRING FASTENERS

GEORGE K. GARRETT COMPANY, INC.

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OTHER QUALITY PRODUCTS BY GARRETT

helical spring lock washers

flat washers

stampings

hose clamps

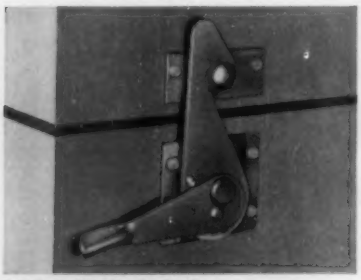
spring washers

CIRCLE 369 ON READER SERVICE CARD 369

FASTENING AND JOINING

ANSWERS to specific fastening problems ...by SIMMONS

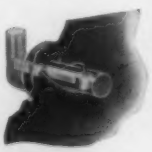
Economy, design flexibility, quick and easy installation, strength, and smooth, dependable action are advantages of these Simmons Fasteners, made for a variety of special applications. Whatever your fastening problem, engineering aid is available from Simmons.



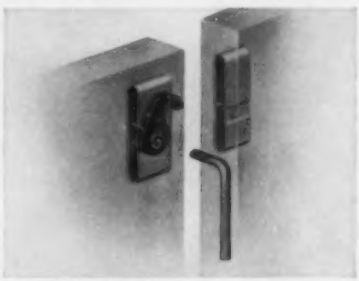
HOOK-LOCK–Springless, positive-locking latch which lies flat against mounting surface, open or closed. Provides high closing pressure and load-carrying capacity. For military as well as commercial container applications.

SPRING-LOCK–Perfect, proved blind rivet for removable covers and panels on electric and electronic equipment, sheet-metal automobile parts, appliances.

Plastic Spring-Lock Shelf Supports with "heart of steel" help refrigerator makers cut costs, speed production, simplify servicing.



LINK-LOCK–Ideal latching device where heavy locking pressure is necessary. Available in heavy, medium, light duty, for use in military and commercial containers and demountable construction.



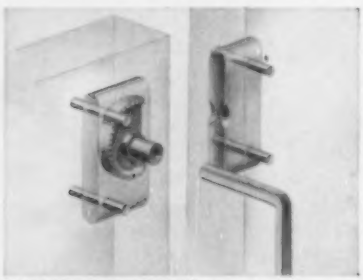
DUAL-LOCK–Impact and vibration-proof high-load butt-joint fastener that will not accidentally unlock or loosen. Recess in panels or surface mount. Withstands 7000-lb. tension.

QUICK-LOCK–For assembling removable panels and access doors. Locked by a 90° turn. Various sizes and types, for weather-tight electrical units, cowlings, access panels.

LINK-LOCK

HINGE-LOCK

HINGE-LOCK–A rugged pressure hinge which provides a strong seal along the hinge line of gasketed equipment containers and transit cases. Matched hardware with LINK-LOCK.



ROTO-LOCK–Versatile fastener for butt or right-angle joints in portable shelters, partitions, knock-down shipping boxes, etc. Solidly built, springless.

CLAMP-LOCK–A simple and strong, positive-locking clamp for fast assembly (and disassembly) of permanent or temporary rooms and buildings of flanged-panel construction.

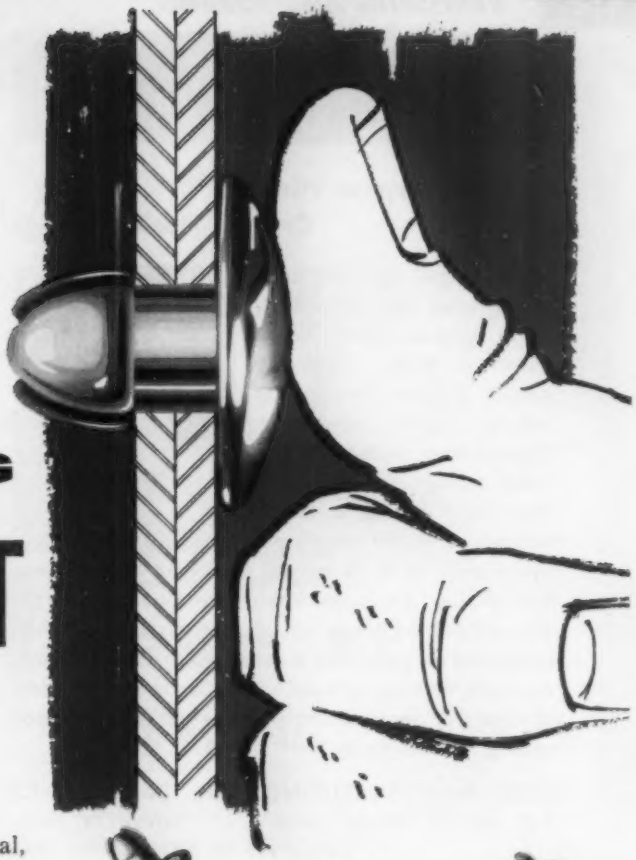
SEND TODAY for your copy of the Simmons catalog, with specifications, applications, installation instructions for all Simmons Fasteners. Samples are available. For special assistance, describe your requirements.

SIMMONS FASTENER CORPORATION

1751 North Broadway, Albany 1, New York

See our condensed catalog in Sweet's Product Design File

to fasten
panels
or parts . . .



LIGHT, STRONG

TRIMOUNT STUDS

Designed for rapid assembly of sheet-metal, plastic or composite structures, Dot Trimount studs are available in both permanent and removable types. They can be pushed into drilled, stamped or molded holes by finger-pressure alone yet they lock positively in place and resist constant vibration.

Studs can be designed in steel or brass with various flange configurations for clinch, clip or clamp attachment to flexible or rigid panels as well as for push-through assembly. Available in all standard finishes . . . with or without decorative caps.

Push Rivet Stud
Shoulder Type (Capped)

Push Rivet Stud
Tapered Type (Capped)

Push Rivet Stud
Shoulder Type (Not Capped)

Push Rivet Stud
Tapered Type (Not Capped)

Clinch Type Stud

Clip-on Stud

Trim Stud
Barrel Type

Trim Stud
Scissors Type

Panel Type Stud

Loop Type Stud

Panel Stud
Staple Type

Panel Stud
Hook-on Type

DESIGN ENGINEERING SERVICE

Designers, metallurgists and plastics specialists on Dot's engineering staff are equipped to work out optimum combinations of metal and plastics to suit your particular requirements.

▶ *For further details, write for Engineering Data Catalog, Section H*

MAKERS OF DOT FASTENERS

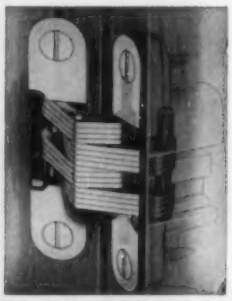
CARR FASTENER COMPANY

Division of United-Carr Fastener Corporation, Cambridge 42, Mass.

Offices in: Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Kalamazoo, Los Angeles, Louisville, New York, Philadelphia, Syracuse

NEW INVISIBLE HINGES

General Purpose Hinge Creates Flush Surfaces

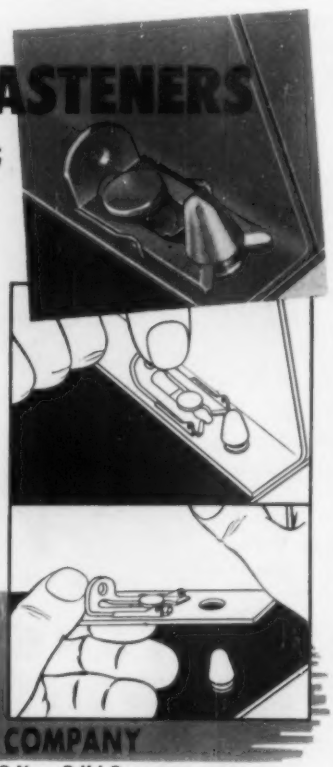


These hinges are completely hidden from view when door, lid or hood is closed. Makes possible flush, absolutely smooth surfaces that greatly enhance appearance and safety. Tapered body sections are precision castings of a special zinc base alloy having a tensile strength of 47,000 pounds per square inch. Operates in a 180 degree arc which permits full opening. Laminated link construction reduces friction and permits hinges to operate freely and smoothly. Hinges are reversible and may be used right or left hand. Available for wood or metal application in a wide variety of sizes. For complete details, prices and free illustrated catalog, write today to

SOSS MANUFACTURING CO., Dept. PER-13
P.O. Box 38, Harper Station, Detroit 13, Mich.

CIRCLE 658 ON READER SERVICE CARD

DIMCO-GRAY SNAPSLIDE FASTENERS



PROVIDE VIBRATION-PROOF HOLDING AND QUICK, FOOL-PROOF RELEASE!

APPROVED UNDER ARMY-NAVY STANDARDS

Here's a simple, easy means of securely fastening assemblies to withstand shock or vibration, *and yet allow quick removal for inspection or repair.* Instant snap action engages or releases fastener . . . no tools are required! After installation, fasteners never need adjustment . . . even with repeated use.

Three sizes available for different load requirements. Large and medium sizes are made of corrosion-resistant *stainless steel.* Small size is made of nickel-plated brass. Stock parts fit various thicknesses of flanges and mounting plates . . . special parts can also be supplied.

WRITE FOR FULL DETAILS TODAY!

DIMCO-GRAY COMPANY
202 E. SIXTH STREET DAYTON, OHIO

catalogs and bulletins.....continued

(G-76) **Phillips Head Screws**—Manual. Furnishes specifications and standards for screws and driver-bits. Also has information on quality control and inspection techniques, driving methods. Screw Research Association, 161 Prescott St, E Boston 28, Mass.

(G-77) **Weld Fasteners**—Brochure, 8 pp. Gives dimensions of screws, studs, nuts, pins designed for projection welding. Also spot weld nuts. The National Screw & Mfg Co, 2440 E 75 St, Cleveland 4.

(G-78) **Threaded Inserts**—Catalog, 14 pp. Gives dimensions, strength, installation and removal data for internally threaded, externally threaded and other types. Newton Insert Co, 6500 Avalon Blvd, Los Angeles 3.

(G-79) **Self-locking Fasteners**—Catalog, 23 pp. Presents dimensions, strength, physical properties of bolts, screws, nuts utlizing nylon pellet inserts. The Nylock Corp, 611 Industrial Ave, Paramus, NJ.

(G-80) **Nylon Fasteners**—Catalog, 8 pp. Gives dimensions of machine screws, cap screws, set screws, nuts. Lists properties of nylon. Nylogrip Products, 570 Pleasant St, Watertown, Mass.

(G-81) **Blind Rivets**—Brochure, 4 pp. Gives materials and dimensions of hand-hammer-driven rivet for wood, plastic, metal. Olympic Screw & Rivet Corp, 11445 Dolan St, Downey, Cal.

(G-82) **Coatings and Adhesives**—Catalog, 8 pp. Presents tables of uses, application methods for compounds used on wood, metal, plastic, fabrics, leather, others. Price & Stevens Chemical Corp, 710 Ohio St, Buffalo 3, Ohio.

(G-83) **Retaining Rings**—Catalog, 36 pp. Provides design data, dimensions and installation instructions for spiral wound and snap rings. Ramsey Corp, Box 513, St Louis 66.

(G-84) **Film Adhesive**—Bulletin, 6 pp. Phenolic, waterproof adhesive is in form of continuous roll of film. Uses include plywood gluing, laminating and metal bonding. Reichhold Chemicals, Inc, 525 N Broadway, White Plains, NY.

(G-85) **Continuous Hinges**—Catalog, 12 pp. Diagrams hinges for control cabinets, metal panels, aircraft. Tables give sizes. Standard length is 72 in. The Rex Hinge Co, 1540 Coit Ave, E Cleveland 12, Ohio.

continued

ELCO®

COLD-HEADED SPECIAL PARTS

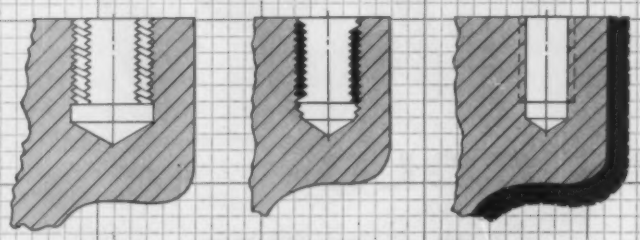
Substantial savings are often achieved through the use of low-cost cold-headed parts in place of complex assemblies or pieces requiring several machining operations. The examples shown here represent a wide variety of possibilities, yet these are only a few of the thousands we have produced. Our sales engineers and field representatives are ready to give you skilled advice on potential adaptations to *your products. Just call your Elco man.*

ELCO TOOL AND SCREW CORPORATION

1135 SAMUELSON ROAD, ROCKFORD, ILLINOIS

CIRCLE 373 ON READER SERVICE CARD 373

How You Can Save Boss Space and Weight in Thread Design ...with HELI-COIL® Inserts



Solid bushing requires oversize boss

Heli-Coil Insert permits standard boss proportion

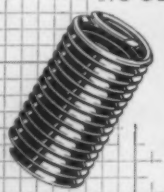
Space and weight saved by *Heli-Coil* Insert

As seen in the illustrations above, *Heli-Coil* Inserts save 56% in space, 63.5% in weight.

Heli-Coil stainless steel wire inserts have a smaller outside diameter than any solid bushing. Therefore, with *Heli-Coil* Inserts you can design boss radii to a minimum, yet stay with standard boss configurations. This means *savings in space and weight*, and material-savings as well.

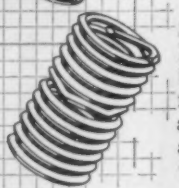
This feature is vitally important for miniaturization in aerospace design, in electrical and electronics equipment design, and for general industrial applications.

NO OTHER TYPE OF INSERT OFFERS SUCH SAVINGS!



Heli-Coil Screw-Thread Insert

Permanently protects threads against wear, stripping, corrosion, galling, seizing, vibration and shock. Made of 18-8 stainless steel wire, cold-formed into a diamond-shaped cross section, work-hardened to a tensile strength of approximately 200,000 psi. Conforms to mil specs and all commercial and industrial thread forms.



Heli-Coil Screw-Lock Insert

Provides same protection as Screw-Thread Insert, PLUS an exclusive *patented* resilient *internal* locking feature that eliminates protruding lock nuts, lock wiring and other supplementary locking devices, thus saving additional space and weight. Meets military specifications for locking torque and vibration.

The Heli-Coil line of products includes: inserts and related taps, tools and gages. Tables of boss radius and weight comparison are available.

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 609 Shelter Rock Lane, Danbury, Connecticut
I'd like more information on *Heli-Coil* Screw-Thread Inserts ☐ Screw-Lock Inserts ☐

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FIRM _____
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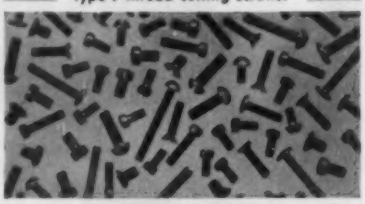
CITY _____ ZONE _____ STATE _____ 2565

In Canada: ARMSTRONG BEVERLEY ENGINEERING LTD.
6975 Jeanne Mance St., Montreal 15, Que., Crescent 4-3538

IT PAYS TO HAVE HUBBELL SCREW CONNECTIONS

COLD HEADED ROLLED THREAD
PRECISION
FASTENERS

STANDARD AND BINDING HEAD SCREWS
Slotted, Phillips, Sems; also type A, B and C Tapping Screws and type F thread cutting screws.



MINIATURE FASTENERS
Sizes #0 and #1 Steel, Stainless Steel, Brass.

COLD HEADED PARTS, RIVETS, STUDS
Custom designed. Large production facilities.

HEADS Flat, Round, Oval, Fillister, Binding, Truss, Jackson, Washer, Pan, Knurled, Depressed Hex Head, Sems Fastener Units with Attached Shakeproof or split-type lock washers.

METALS Brass, Steel, Stainless Steel, Monel, Nickel Silver, Aluminum, Silicon Bronze, Commercial Bronze.

FINISHES Nickel, Cadmium, Zinc, Brass, Bronze, Chrome, Parkerizing, Iridite, Blued.

HARVEY
HUBBELL,
INCORPORATED
MACHINE SCREW DEPARTMENT
BRIDGEPORT 2, CONNECTICUT

catalogs and bulletins.....continued

(G-86) **Adhesive Selection** – Brochure, 8 pp. Discusses points to consider when choosing an adhesive. Rubber & Asbestos Corp, 225 Belleville Ave, Bloomfield, NJ.

(G-87) **Socket Screws**–Catalog, 23 pp. Prices and dimensions listed for set, button head, shoulder screws and others. Safety Socket Screw Co, 6501 N Avondale Ave, Chicago 31.

(G-88) **Water Tight Bolts**–Brochure, 4 pp. Presents dimensions and physical properties of bolt for use in wood. Screw & Bolt Corp of America, 211 Farmers Bank Bldg, Pittsburgh.

(G-89) **Hot Formed Nuts**–Brochure, 4 pp. Describes physical properties and advantages of nut made by process utilizing induction heating and upsetting. Screw & Bolt Corp of America, 211 Farmers Bank Bldg, Pittsburgh.

(G-90) **Lockwasher and Nut**–Catalog, 8 pp. Tables give sizes of combinations of several types of lockwashers attached to nuts. Shakeproof Div of Ill Tool Works, St Charles Rd, Elgin, Ill.

(G-91) **Thread-cutting Screws**–Catalog, 32 pp. Provides strengths, tightening torques, sizes and head shapes. Table matches screw to metal or plastic and gives hole size. Shakeproof Div of Ill Tool Works, St Charles Rd, Elgin, Ill.

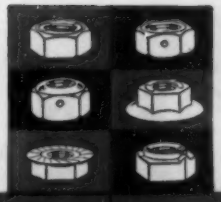
(G-92) **Lockwasher-screw Units**–Catalog, 36 pp. Sketches and tables show dimensions, head and washer styles of preassembled combinations. Shakeproof Div of Ill Tool Works, St Charles Rd, Elgin, Ill.

(G-93) **Lockwashers**–Catalog, 32 pp. Types dimensioned include: dome, tab, sealing, cup, countersunk and 10 others. Shakeproof Div of Ill Tool Works, St Charles Rd, Elgin, Ill.

(G-94) **Screws and Bolts**–Catalog, 58 pp. Contains data on wood, machine, tapping, drive and dowel screws; stove, carriage and hanger bolts; and continuous threaded studs. Southern Screw Co, Box 1360-PE, Statesville, NC.

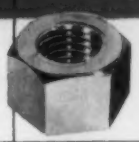
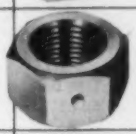
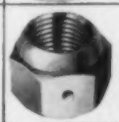
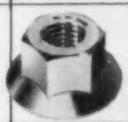
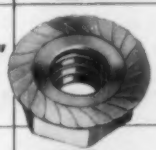
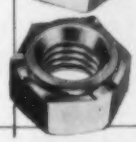
(G-95) **Ratchet Wrenches**–Brochure, 4 pp. Lists sizes and special features of five series of square and hexagon head wrenches. They range from light to very heavy duty. Lowell Wrench Co, 97 Temple St, Worcester, Mass.

continued



One of these CAN IMPROVE YOUR PRODUCT...

SIX GREAT
MACLEAN-FOGG
LOCK NUTS

MF **UNI-TORQUE**		A free starter with lock at the top. Withstands severe vibrations. Cuts assembly time.
MF **TWO-WAY**		The Lock's in the center of nut. Can be applied from either end. Permits bolt end to be flush with, or below, top of nut.
MF OPEN END **CAP NUT**		Has two-way center-of-nut lock. Used on furniture, appliances, toys, lawn mowers, tools, etc.
MF UNI-TORQUE **FLANGE NUT**		Combination lock nut and washer. Use on oversized holes; where extra bearing surface is needed.
MF **"WHIZ-LOCK"** FLANGE NUT		This one spins on. Serrations take a firm grip on work. Break loose torque higher than seated torque.
MF PILOT TYPE **WELD NUT**		You can have it with or without lock. Simplifies assemblies by means of self-locating pilot.

CIRCLE NUMBER FOR ILLUSTRATED CATALOG

SEE OUR CATALOG IN SWEET'S

MAC LEAN-FOGG MF LOCK NUTS

MacLean-Fogg Lock Nut Company
5535 N. WOLCOTT AVENUE
CHICAGO 40, ILLINOIS

1925 35 1960 ANNIVERSARY

R B&W
116th year

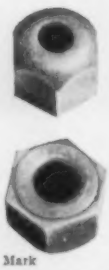
FASTENERS THAT SOLVE SPECIAL PROBLEMS

TENSILOCK® SCREWS AND NUTS

"Tensilock," the high tension locking fastener, bites with hardened ratchet teeth . . . holds tight. High residual tension, tooth grip, and spring action of flexible flange make required loosening torque as much as 40% more than tightening torque. ©TM

PIGMENTED DELRIN® LOCK NUTS

RB&W open-end acorn nuts of pigmented Delrin feature excellent strength, rigidity, dimensional stability, low cost, reusability, corrosion resistance. Constant prevailing torque. Metallic gray and other colors. Two sizes: No. 10 develops 500-600 lbs. clamping force; ¼-inch develops 600-700 lbs.

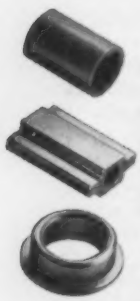


®Dupont Trade Mark

SPIN-LOCK SCREWS

These RB&W screws offer in flat head and filister head design a locking action similar to that of RB&W's Tensilock® screws. They have ratchet-like teeth that bite into the bearing surface when tightened and resist loosening from vibration or temperature cycling. Reusable. Wide range of sizes.

POWDERED METAL PARTS



A variety of small parts is presently being produced by RB&W from powdered brass and stainless steel. Facilities can handle a wide variety of other small shapes, including nuts, gears, bushings, spacers, levers, cams, etc. Such sintered parts offer substantial production savings. Contact us with your requirements.

STAKED LOCK NUTS

Staked on opposite sides for positive grip and spring tension locking effect. Available in regular double chamfered style or acorn style (illustrated), in aluminum, steel, silicon bronze.

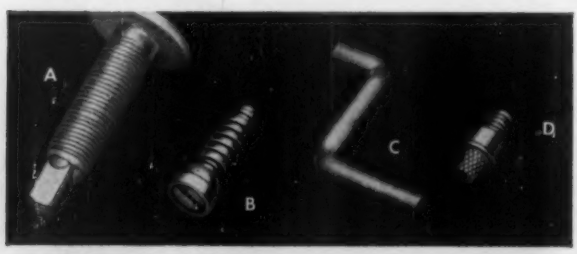
WELDING FASTENERS

RB&W standard welding screws have welding projections on top or bottom of head. Sizes from No. 6 through ½ inch. Welding Nuts can also be supplied.

Cold heading creates quality parts the low cost way

METAL FORCED to cold flow into shape results not only in savings but also in stronger parts. With uncut flow lines, the piece is better able to withstand stress concentrations.

No value analysis of product components is really complete without exploring what cold heading machines can do. Some examples:



ELIMINATE EXTRA OPERATIONS. Leveling screw (A), formerly made by riveting flat disc to set screw, now emerges as a stronger, single piece from a cold header.

ONE PIECE BETTER THAN TWO. Cold headed hose clamp screw (B) has integral flange which, after head is slotted, is forced up to form screwdriver shield. Before, piece was in two parts . . . with screw made on screw machine, and the shield a stamping fitted around head in extra assembly operation.

FASTER THAN FORGING. Shifter lever (C) is bent into double "L" automatically in bolt header . . . replacing 2-stage forging operation. The header does it at high speed from continuous rod.

METAL FLOWS TO SHAPE—NO WASTE. No longer cut on screw machine, insert screw (D) for plastic parts cost 40% less. Cold header uses just the amount of metal required. The threading and knurling, too, are done automatically at high speed.

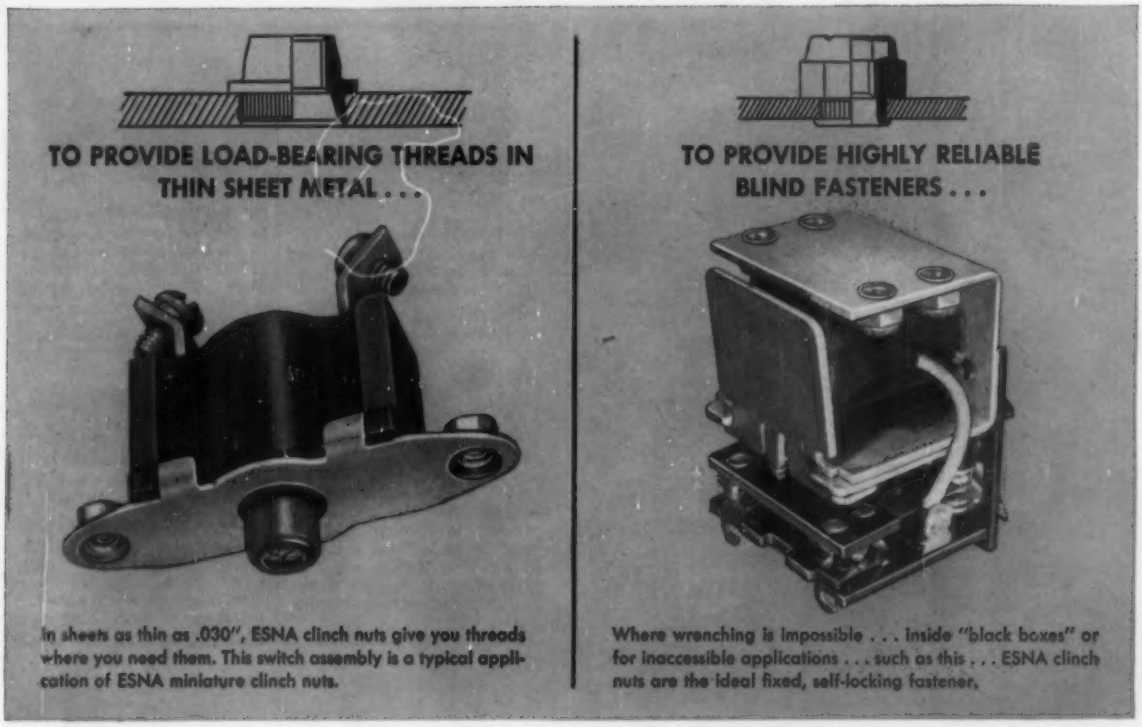
RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

RB&W fasteners—Strong Point of any assembly

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.) Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

See our catalog in Sweets Product Design File

Where can you use an ESNA Clinch nut?


TO PROVIDE LOAD-BEARING THREADS IN THIN SHEET METAL . . .
In sheets as thin as .030", ESNA clinch nuts give you threads where you need them. This switch assembly is a typical application of ESNA miniature clinch nuts.
TO PROVIDE HIGHLY RELIABLE BLIND FASTENERS . . .
Where wrenching is impossible . . . inside "black boxes" or for inaccessible applications . . . such as this . . . ESNA clinch nuts are the ideal fixed, self-locking fastener.

PREFERRED INSTALLATION METHODS

USE A HAND TOOL for short run or prototype assembly. (Not recommended for volume production).

USE A DRILL PRESS—"spinning" technique provides highest quality installation and reliability.

USE A HAND RIVETER —pressure applied by a gradual "squeeze."

USE AN ARBOR PRESS or comparable light power press.

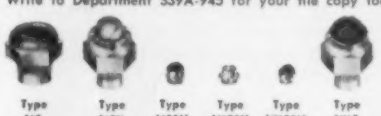
Why an ESNA Clinch nut?

The reasons are simple:

The ESNA clinch nut line includes sizes, shapes and materials to fit any possible application. For example:

1. A weight-saving nut with very small dimensions that can be mounted "flush" in sheets as thin as .030". (See the new miniature clinch nut designs on Pages 12, 14 of Design Manual No. 5803).
2. A part with non-magnetic characteristics . . . or with full self-locking reliability at temperatures as high as 900° F. (Check ESNA's A286 stainless steel miniatures on Page 15).
3. A capped type of clinch nut that will keep screw threads free from potting compounds; or that can be used to protect vital wiring from abrasion by protruding screw ends. (ESNA shows a full line of nylon or metal capped clinch nuts on Pages 10, 11, 13).

ESNA Electronic Fastening Design Manual No. 6013 will give you complete details on the full line of ESNA Clinch nuts and special purpose designs for electrical assemblies. Write to Department 539A-945 for your file copy today.



Type NC | Type NCK | Type NCFM | Type LHCFM | Type NKCFM | Type NKC

The ESNA line offers two locking devices:

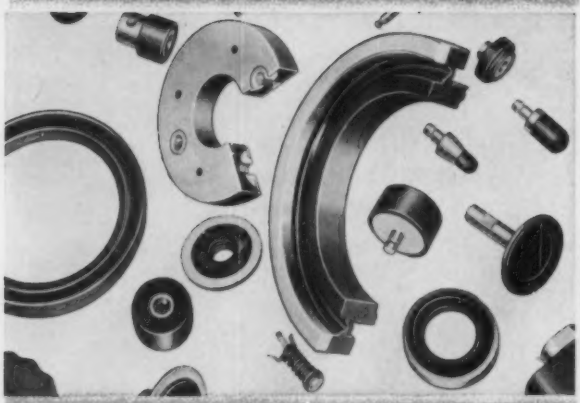
The famous red nylon locking collar for application at temperatures to 250° F.; and the offset locking oval for applications up to 550° F. and 900° F.

ELASTIC STOP NUT CORPORATION OF AMERICA

2330 Vauxhall Road, Union, New Jersey

539-91 for your free copy today.

have a BONDED to METAL problem?



FOR CUSTOM COMPOUNDED PRECISION FABRICATED

Go Goshen **RUBBER**

BONDED TO METAL PRODUCTS

The unique GORBOND process developed by Goshen Rubber permits parts fabricated from natural, synthetic and silicone rubbers, to be bonded to metal, plastics and most anything . . . to meet customer satisfaction. Facilities are complete and modern, for efficiently handling large and small quantities.

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Goshen Rubber Co., INC.

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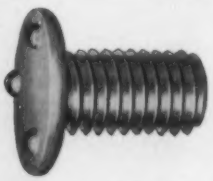
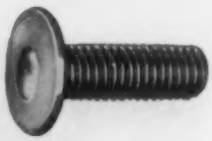
OHIO WELD SCREWS



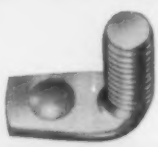
GW SCREWS—Used where design requires a smooth unmarred surface and a fastener permanently fixed in place.



HH SCREWS—Used where a single, button-type projection is required when welding to curved surfaces, to heavy sheet $\frac{3}{32}$" or thicker, or to ends of rods.

HW SCREWS—Used where a self-locking through bolt is required to be fixed securely in place so that it will not turn and flush surface is required for attaching mating parts.

RW SCREWS—Used where a hermetic seal is required to prevent leakage of air, gas, water, oil or dust, or when welding to perforated metal or wires.



DW SCREWS—Used where a projection weld screw is required and confined location necessitates a narrow head.

SS SCREWS—Used where a screw with narrow head is required to be spot welded in place.

PD SCREWS—Used where it is desirable to place a threaded section on the edge of a sheet.

CS SCREWS—Used where a hermetic seal and a screw are needed on both sides of the sheet as on transformer can relay points.

In addition to weld screws, Ohio stocks a complete line of weld nuts—12 different styles—for both projection and spot welding. Write for the complete Ohio catalog.

Samples and information available upon request.

The OHIO WELD FASTENERS Primary Fastener in Fastener Assemblies

THE OHIO NUT AND BOLT CO.

41 FIRST STREET BEREA, OHIO

catalogs and bulletins.....continued

(G-96) **Socket Screws**—Catalog, 82 pp. Describes large variety of socket screws including locking types. Also dowel pins. Standard Pressed Steel Co, Jenkintown, Pa.

(G-97) **Cap Screws**—Catalog, 24 pp. Presents dimensions, physical properties for several types of cap screws plus set screws, taper pins, studs and nuts. Standard Screw Co, 2701 Washington Blvd, Bellwood, Ill.

(G-98) **Socket Screw Products**—Catalog, 26 pp. Contains dimensions and physical properties. Includes hexagon keys, dowel pins. Standard Screw Co, 2701 Washington Blvd, Bellwood, Ill.

(G-99) **Socket Head Cap Screws**—Brochure, 6 pp. Provides dimensions and makes comparison with company's previous design with smaller head and socket. Standard Screw Co, 2701 Washington Blvd, Bellwood, Ill.

(G-100) **Hex Screws**—Brochure, 6 pp. Provides tables for dimensions for hex screws, carriage bolts, lag screws plus nuts. Standard Screw Co, 2701 Washington Blvd, Bellwood, Ill.

(G-101) **Quick-release Tiedowns**—Brochure, 4 pp. Tiedowns come with working load ratings of 500 to 5000 lbs. A 40° turn releases. Monadnock Mills, 1977 First Ave, San Leandro, Cal.

(G-102) **Stainless Steel Fasteners**—Catalog, 24 pp. Provides materials specifications, corrosive service ratings, dimensions of stainless steel and nylon fasteners, stainless pipe fittings. Star Stainless Screw Co, 655 Union Blvd, Paterson 2, NJ.

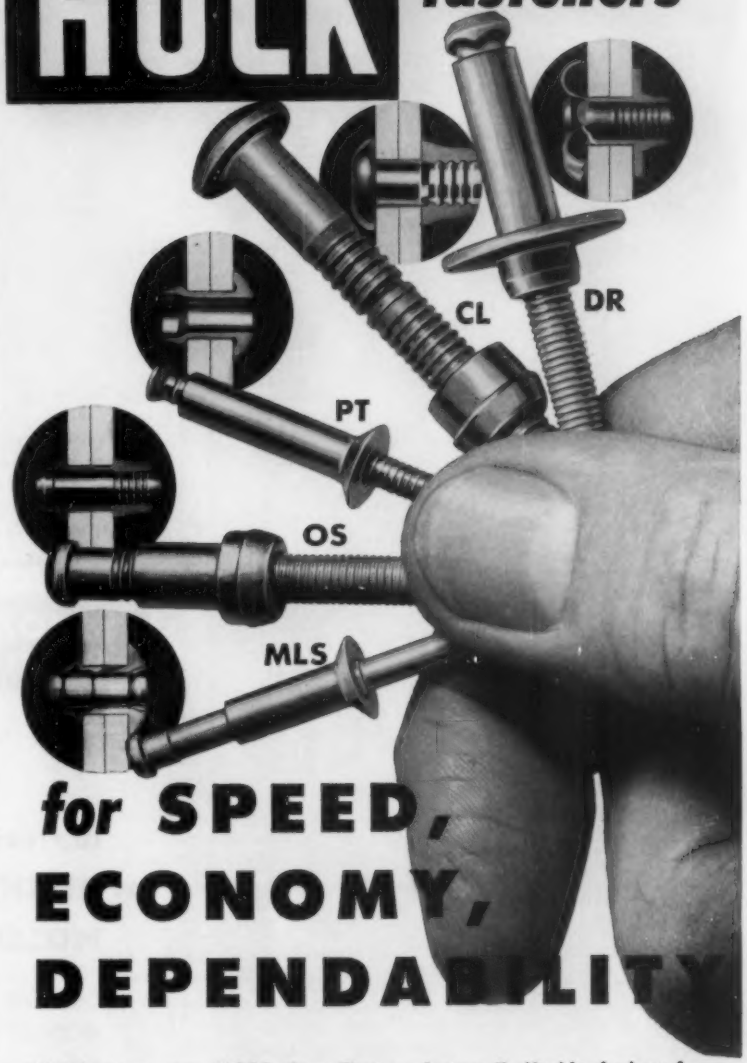
(G-103) **Screws and Washers**—Catalog, 8 pp. Tabulates dimensions, shows heads, threads and points. Includes regular and thread-cutting screws; lock, spring, special washers; preassembled screw and washer combinations. Thompson-Bremer & Co, 228 N LaSalle St, Chicago 1.

(G-104) **Fasteners**—Bulletin, 18 pp. Describes applications of fasteners made of sheet metal including nut into which screw is snapped on installation. Tinnerman Products, Inc, Box 6688, Cleveland 1.

(G-105) **Fasteners**—Brochure, 12 pp. Outlines facilities and selection of locknuts, lockbolts, rivets and others. Engineered Fasteners Div, Townsend Co, Box 71, Ellwood City, Pa.

continued

HUCK fasteners



for SPEED, ECONOMY, DEPENDABILITY

HUCK gives you MORE than "just a fastener". Huck's foolproof installation tools, convenient power units and versatile fasteners give you uniformity and speed of installation beyond your fondest hopes, even with inexperienced operators. Savings of up to seventy per cent on installed cost have been obtained by many users of Huck fasteners.

There is a HUCK fastener to meet your specific requirements whether they be high tensile or shear strength, blind application, thin sheets, wood-to-metal, broad bearing area, flush installation, high clinch, positive mechanical lock, elevated temperature, corrosion resistance or speed of application. A phone call can save you important production dollars. It costs you nothing to find out.

We invite your inquiries.

HUCK MANUFACTURING COMPANY

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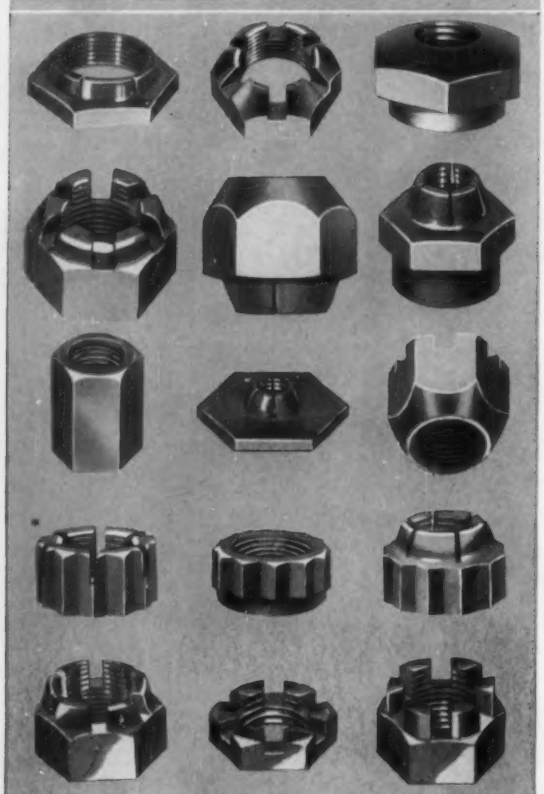
CIRCLE 379 ON READER SERVICE CARD 379

SPECIAL NUTS

to specs. 3/8" - 4-1/4" cross flats

special machines + large stock of material x years of experience = speedy deliveries high quality low prices



Here are a few samples made to customers specifications . . Our batteries of special high-speed multi-spindle, automatic machines make possible fast and accurate production of hexagon nuts of non-standard height and special shape from carbon or alloy steel, Naval bronze or other non-ferrous metals; also AN 310 through AN 335 as per latest Airforce specifications. Very often the special nut you require may be similar to one we are already making and a simple modification would result in a price advantage and quicker deliveries to you . . Send us your blueprint and particulars —let us quote on your requirements . . We also have a catalog that contains complete specifications, engineering data and prices regarding our standard nuts.

*12 Pointer Standards, sizes: ¼" to ¾"—brochure on request

NATIONAL MACHINE PRODUCTS

*Manufacturer of Standard and Special *12 Pointer and Hexagon Nuts..."Huglock" and "Marsden" lockNuts.*

44225 Utica Rd., UTICA, Michigan

an SPS/COMPANY

for fastening small assemblies

specify **MOORE MINIATURE** headless slotted **SET SCREWS**

. . . simplify design, purchasing, production

Here's your fast, dependable source for Miniature Headless Slotted Set Screws. Available in sizes #0 through #4 in a wide selection of materials, finishes, lengths and points. These miniature set screws are made to the same accuracy and high quality standards as regular size Moore Set Screws.

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CIRCLE 661 ON READER SERVICE CARD

design manual on

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Combined reprint of 11 articles published in PRODUCT ENGINEERING offers detailed design data on the seven processes suitable for making glass-reinforced plastic parts in commercial volume.

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catalogs and bulletins.....continued

(G-106) Titanium Fasteners—Brochure, 12 pp. Compares titanium with steel for aircraft fasteners. Standard Presssed Steel Co, Jenkintown, Pa.

(G-107) Strap Wrenches—Brochure, 6 pp. describes wrenches for turning diameters from one to 12 in. Special length straps are available. Lowell Wrench Co, 97 Temple St, Worcester, Mass.

(G-108) Locknuts—Brochure, 4 pp. Shows a locknut that is designed to bite into metal and eliminate lockwashers. Lists some companies and products using them. The Waterbury Pressed Metal Co, 300 Chase Ave, Waterbury, Conn.

G-109) Bolt-rivet—Bulletin, 4 pp. Provides strength and fatigue data plus dimensions of a fastener with controlled preload. Also designed for light weight. Hi-Shear Rivet Tool Co, 2600 W 247 St, Torrance, Cal.

(G-110) Snaps, Large Washers, Links—Brochure, 4 pp. Lists sizes of above items plus wing nuts, chain swivels, wire rope clips and others all made of malleable iron. Moline Iron Works, Moline, Ill.

(G-111) Rivets—Brochure, 4 pp. Describes a variety of rivets and rivet-setting machines. Includes a table of clinch allowances. Chicago Rivet & Machine Co, 950 S 25 Ave, Bellwood, Ill.

(G-112) Screws and Bolts—Brochure, 4 pp. Explains cold-heading process company uses to make standard and special screws and bolts. National Lock Co, 1902 Seventh St, Rockford, Ill.

(G-113) Air Frame and Engine Fasteners—Brochure, 4 pp. Describes titanium and super alloy precision fasteners, some custom, some standard and some proprietary. Voi-Shan Mfg Co, 8463 Higuera St, Culver City, Cal.

(G-114) Blind Nut—Brochure, 4 pp. Explains use of nut that grips any material from zero to ¾ in. thick and can also act as a rivet. Includes table of specifications. Molly Corp, Reading, Pa.

(G-115) Industrial Fasteners—Catalog, 40 pp. Describes a wide range of fasteners. Furnishes engineering data and suggests uses. Simmons Fastener Corp, 1751 N Broadway, Albany 1, NY.

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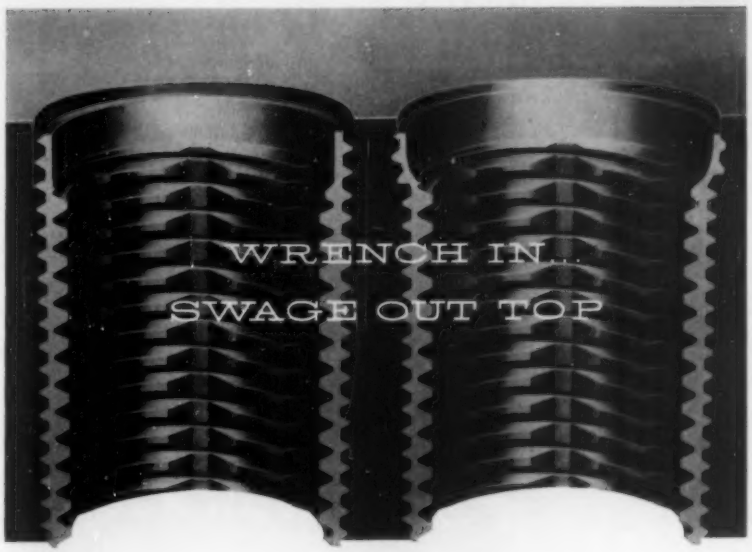

ONE PIECE
LOCKING INSERT

SLIMSERT*.. WRENCH IN and SWAGE OUT TOP to complete the simple installation of SLIMSERT inserts after hole preparation with standard drill and tap.

SLIMSERT .. IDENTIFICATION is easy BEFORE and AFTER installation; The new Long Life 360° internal thread locking SLIMSERT inserts have 6 POINT wrenching recesses. Those without the internal thread locking feature have 4 POINT wrenching recesses. All SLIMSERT inserts have an external serrated area at the top which is swaged outward into the parent material with a Rosan engineered swage tool. Locking meets and exceeds the requirements of MIL-N-25027 specification. SLIMSERTS are made from ARMCO** 17-4PH Stainless Steel or Hi-Strength Aluminum Alloy.

Write for free 20 page descriptive book.

4 POINT NO INTERNAL THREAD LOCK

6 POINT 360° INTERNAL THREAD LOCK

SLIMSERT*

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Designers and Manufacturers of the World's Finest Precision Fasteners

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CIRCLE 381 ON READER SERVICE CARD 381

THE

CP

ON EVERY

CHANDLER

CAP SCREW

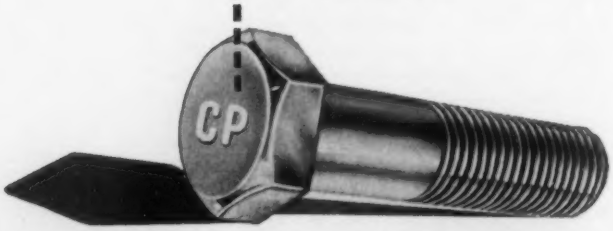
IS YOUR

GUARANTEE OF

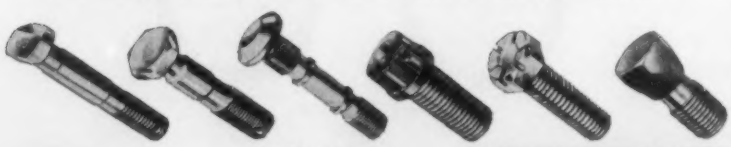
QUALITY

UNIFORMITY AND

PRECISION!



This trademark — *CP* — is your assurance of engineered quality from start to finish . . . your guarantee of functional dependability . . . your security that every cap screw has successfully met rigorous performance tests. Chandler Products . . . manufacturers of standard and special fasteners for over 30 years . . . mass-produces cold-headed cap screws from high carbon, alloy, super-alloy and stainless steels. *Check with Chandler* before placing your next order.



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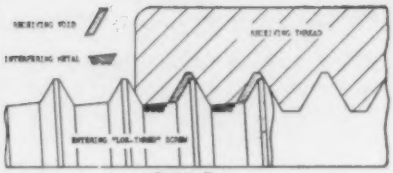

Figure No. 11

ILLUSTRATION SHOWS

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catalogs and bulletins.....continued

(G-116) Special Fasteners—Catalog, 44 pp. Provides specifications, engineering drawings, installation details and suggested uses for many kinds of fasteners. Simmons Fastener Corp, 1751 N Broadway, Albany 1, NY.

(G-117) Blind Rivets—Catalog, 44 pp. Gives descriptions and standards for aircraft and commercial rivets in aluminum, monel, mild steel and A286 stainless steel. Cherry Rivet Div, Townsend Co, Santa Ana, Cal.

(G-118) Lockbolts—Catalog, 44 pp. Bolts of aluminum, mild steel, alloy steel and A286 stainless steel are for aircraft and commercial use. Includes bolt standards. Cherry Rivet Div, Townsend Co, Santa Ana, Cal.

(G-119) Fastener Advice—Brochure, 8 pp. Discusses several examples of savings made in mass-production assembly by asking company's advice. Shakeproof Div of Ill Tool Works, St Charles Rd, Elgin, Ill.

(G-120) Aluminum Chain—Brochure, 6 pp. Lists sizes, weights and load limits of seamless, weldless chain. Load limits vary from 500 to 10,000 lbs. Bison Aluminum Chain Co, Inc, 241 Hertel Ave, Buffalo 7, NY.

(G-121) Fasteners—Data folder, 5 pp. Contains data on materials, dimensions, and finishes of flat spring fasteners, screw machine products, retaining rings, nuts and hairpin spring fasteners. Stanley-Humason, Inc, subs of The Stanley Works, Forestville, Conn.

(G-122) Clamps—Catalog, 70 pp. Engineering drawings plus tables give dimensions and materials. Clamps are for supporting electrical, electronic, hydraulic and pneumatic lines. TA Mfg Co, 4607 Alger St, Los Angeles.

(G-123) Quick-release Pins—Bulletin, 6 pp. Pins lock positively yet release quickly even when bound. Diameters are $\frac{1}{8}$ to 1 in. Avdel, Inc, 210 S Victory Blvd, Burbank, Cal.

(G-124) Riveter and Rivets—Brochure, 4 pp. Describes pneumatic riveting guns, automatic hand riveter and hand riveters for use where access is difficult. Riveters perform blind or open riveting. Avdel, Inc, 210 S Victory Blvd, Burbank, Cal.

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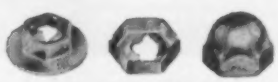

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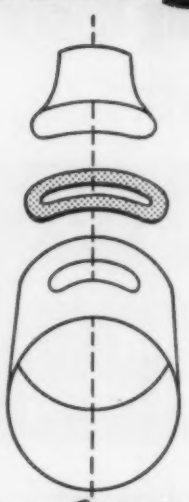

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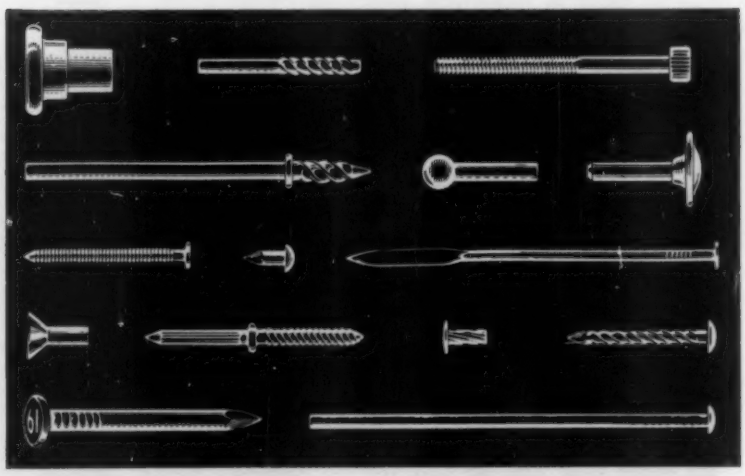

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catalogs and bulletins.....continued

(G-125) **Bolts**—Brochure, 4 pp. Outlines selection of standard, special and aircraft bolts. Lists special techniques company can use. Chandler Products Corp, 1460 Chardon Rd, Cleveland.

(G-126) **Large Hot Pressed Nuts**—Bulletin, 4 pp. Lists dimensions, materials, threads, weights of square and hexagon nuts for bolts up to 4 in. diameter. Joseph Dyson & Sons, Inc, 5125 St Clair Ave, Cleveland 3.

(G-127) **Chains**—Two bulletins, 4 pp. Gives sizes, weights and working loads for welded carbon and alloy steel chain and attachments. Columbus McKinnon Chain Corp, Tonawanda, NY.

(G-128) **Self-locking Screws and Bolts**—Brochure, 8 pp. Table gives sizes and torque values for fasteners with a nylon insert. Continental Screw Co, 452 Mt Pleasant St, New Bedford, Mass.

(G-129) **Self-locking Screws**—Brochure, 4 pp. Describes screws that have gripping teeth under head. Head types are hex, pan and flat. Sizes are ¼ in. diameter and larger. Screw & Bolt Corp of America, 211 Farmers Bank Bldg, Pittsburgh.

(G-130) **Aircraft Fastener**—Bulletin, 24 pp. Explains how a modified cruciform head recess allows high torquing without burring. American Screw Co, Willimantic, Conn.

(G-131) **Fasteners**—Brochure, 6 pp. Provides a general picture of company's products, facilities and techniques. Standard Screw Co, 2701 Washington Blvd, Bellwood, Ill.

(G-132) **Self-sealing Panel Fastener**—Brochure, 4 pp. Nylon ring under head of stud seals against moisture. Gives full dimensions of all parts. Monadnock Mills, 1977 First Ave, San Leandro, Cal.

(G-133) **Wire Harness Bands**—Catalog, 16 pp. Aircraft quality bands are sponge-lined. They attach to support by clips, rivets or spring stud. Monadnock Mills, 1977 First Ave, San Leandro, Cal.

(G-134) **Quick-locking Panel Fastener**—Catalog, 20 pp. Quarter turn locks removable panels in place. Some types seal against pressure and moisture. Monadnock Mills, 1977 First Ave, San Leandro, Cal.

SECTION H

MOTOR, ENGINES AND CONTROLS

Design Abstracts 386

Flexible Engine-suspensions 388

How to Control Speed of Fhp Motors 390

Correcting Motor Power-factor
by G. R. Brooks 392

Operating Principles of 13 Timing Devices
by John C. Ponstingl 393

5 Clutches for Servomechanisms
by Kenneth W. Kohlmeyer 396

Dynamic Response of Remote Pressure Pickups
by Robert J. Reid and Edward M. Kops 401

DESIGN ABSTRACTS

DIESEL ENGINE NOISE

The effect of speed, load and size on noise has been evaluated on a limited range of engines. The following sources of noise have been identified and means of reducing them adequately established in principle. Air intake; valve and timing covers; injection equipment already quietened; injection equipment, normal valve and timing covers; injection equipment, "dead" valve and timing covers.

Narrow band frequency analysis has been shown to be a convenient criterion of the "noisiness" of the form of the cylinder pressure and in conjunction with noise measurement makes it possible to evaluate separately the noisiness of the engine structure. In the small diesel engines tested in this respect, it should be possible to quieten some by smoothing the cylinder-pressure-rise.

Observed levels of vibration of engine surfaces are shown to agree roughly with values calculated from the measured noise and assumed sizes of the radiating parts. A hypothesis is advanced which accounts for the vibration owing to the measured cylinder pressure in the important freqency range from 800 cycles per sec upwards.

"Origins of Diesel Engine Noise," by A. E. W. Austen and T. Priede, C. A. V. Limited, SAE Paper No. 125T, 485 Lexington Ave, New York 17, N. Y.

*

Rocket-motor Gear Analysis

In this paper a rocket-motor turbine-pump reduction gear system is analyzed with regard to Hertzian gear-tooth contact stresses and times of contact. It is found that the Hertzian contact stresses vary from approximately 100,000 to 200,000 psi. Contact times vary from 3 to 8 microsec. Some observations regarding the correlation between contact times and gear failures are made. It is indicated that it may be possible to establish design limitations on the contact times to insure satisfactory gear operation. Sample calculations for evaluating each of the typical quantities found in the tables are included.

"Rocket Motor-Gear Tooth Analysis . . . Hertzian Contact Stresses and Times," Ernest K. Gatcombe and Roy W. Prowell, ASME Paper No. 59-A-256, 29 W 39 St, New York 18, N. Y.

*

Better Spark Plugs

The satisfactory performance of portable 2-stroke engines is being thwarted by short spark-plug life and runaway preignition, which accompanies the high specific output and low weight of these engines. Failures involve many things—cold fouling, lead fouling, bridging, missing, and refusal to start a cold engine.

"Wanted—Better Spark Plugs for Portable 2-Stroke Engines," Lowell E. Haas, McCulloch Corp. SAE Journal, March 1960, 485 Lexington Ave, New York 17, N. Y.

*

Spark Plug Misfiring

Studies of spark plug misfiring due to lead fouling have shown that its severity can be decreased by converting the accumulating deposits to compounds having higher electrical resistance. One way this change can be accomplished is by adding a phosphorus compound to the deposit accumulation fuel.

"Spark Plug Misfiring Can be Decreased," H. P. Julien and R. G. Neblett, Esso Research and Engineering Co. SAE Journal, March 1960, 485 Lexington Ave, New York 17, N. Y.

*

Materials for 1000F Motors

The 1000F motor must not only remain functional at this higher temperature but must also have a high degree of reliability at many different conditions of humidity, temperature vibration, shock, and radiation.

Experience shows that at 1000F the list of suitable materials shrinks. Insulations that might be used are refractory materials, brittle with low expansion coefficients, high moisture absorption, and low elongation. Until someone formulates a mica or ceramic elastomer, 1000F insulation is bound to be thick and have a low effective dielectric breakdown characteristic. This paper presents some ideas on the electrical design which may lead to weight savings and improved reliability.

"The Effect of Properties of Materials for 1000F Motors on Design Voltage for Optimum Specific Output," E. A. Linke, Airborne Accessories Corp. Presented at the SAE National Aeronautic Meeting, Los Angeles, Calif. October 5-9, 1959, Paper No. 112T. Society of Automotive Engineers, Inc, 485 Lexington Avenue, New York 17, New York.

*

Air-supported Vehicles

This paper analyzes the basic principles involved in the operation of all air-supported vehicles proposed to date and classifies them into a minimum number of categories from which all other possible configurations can be evolved by a proper combination of the basic types. Six configurations of these vehicles are: Non-recirculating annular jet; recirculating labyrinth seal; diffuser; plenum chamber; and levapad.

The basic principles involved in the operation of all six configurations are discussed in detail. Seven criteria have been tabulated that compare the six basic configurations with each other.

"Basic Principles of Ground Cushion Devices," Gabriel D. Boehler, Aerophysics Co., Washington 6, D. C. Paper presented at the SAE Annual Meeting, Detroit, Michigan, January 11-15, 1960, Paper No. 133A. Society of Automotive Engineers, 485 Lexington Avenue, New York 17, New York.

*

Transmission Seals

In present-day oil seals, general progress in mechanical shape of oil

seals, when coupled with new synthetic elastomers, has been a large factor in improving performance. For example, a manufacturer can design one seal of Buna-N rubber normally good for 250F and another of polyacrylic normally good for 300F and the Buna-N seal will out-perform the polyacrylic in temperature resistance and life. The better performing seal is a result of three basic design concepts, all contributing to low torque and less drag: Sealing-head design resulting in a narrow shaft contact directly under the garter spring; the rubber head "bonded" to a metal part to eliminate deformation from internal seal assembly pressure or press-fit upset; the rubber mixture compounded specifically as a shaft seal material without deviation required to allow use of non-bonded and less expensive mechanical designs.

"Transmission Oil Seals," G. L. Corsi, Heavy Industry, Nation Seal Div, Federal-Mogul-Bower Bearing, Ind. Paper presented at the SAE National Transportation Meeting, Chicago, Illinois, October 26-28, 1959, Paper No. 119U. Society of Automotive Engineers, 485 Lexington Avenue, New York 17, New York.

*

Rocket-engine Materials

An analysis of material applications in high-temperature environment in rocket engines is made. The problems are examined from the point of view of the designer, the manufacturer, and the quality control engineer. Stringent requirements can be met with relatively common materials by good design and careful manufacturing techniques.

"Application of Materials to High-temperature Service in Rocket Engines," R. P. Fromberg, Rocketdyne Div, North American Aviation Inc. SAE Paper No. 98V, 485 Lexington Ave, New York 17.

*

Wheel Seals

There could be no sealing without both the seal and the shaft, and, therefore, both the shaft and the seal must be included in any comprehensive description of an oil seal. This thought is further enhanced when consideration is given to the influence of the shaft design on the performance of an oil seal. For example, shaft finish, shaft hardness, and the material of which the shaft is made all have important bearing on the successful performance of an oil seal. The oil seal and the shaft must be compatible and the oil seal must be properly installed on the shaft. The shaft must be free of scratches, grind leads and other defects; the shaft periphery must be a perfect circle and the shaft dia must be accurately maintained. The geometry of the shaft must be such that oil is permitted to reach the oil seal lip. Another consideration is the ability of the shaft to conduct heat away from the seal lip.

"Some Recent Developments in Truck Wheel Seals," R. A. Hudson, Chicago Rawhide Manufacturing Co. Paper presented at the SAE National Transportation Meeting, Chicago, Illinois, October 26-28, 1959, Paper No. 119V. Society of Automotive Engineers, 405 Lexington Ave, New York 17, New York.

*

Synchronous Motor Torques Defined

Six commonly used terms for types of torque (rated load, locked rotor, accelerating, pull-in, reluctance, pull-out) are defined and each is discussed. Effects of various factors on torque are illustrated with curves.

"Synchronous Motor Torques Defined," R. C. Morse, Allis-Chalmers Electrical Review, 3rd Quarter, 1959, Milwaukee 1, Wis.

*

Unbalanced Voltage and Motor Performance

A balanced voltage supply is presumed for normal motor characteristics found in association standards and commercial publications. Unbalanced-voltage operation of polyphase induction motors can produce these adverse effects: Speed drops slightly for a given load near full load; efficiency decreases due to additional motor losses; heating is increased by additional losses—losses are greater for motors having skin-effect rotor bars; winding heats unequally because of unequal copper losses in the several phases; line-current unbalance increases much faster than voltage unbalance; normal protective devices may be ineffective; noise and vibration may develop or increase.

'What Is Effect of Unbalanced Voltage On Motor Performance?" R. C. Moore, Allis-Chalmers Mfg Co. Power, September 1959, 330 West 42nd Street, New York 36, New York.

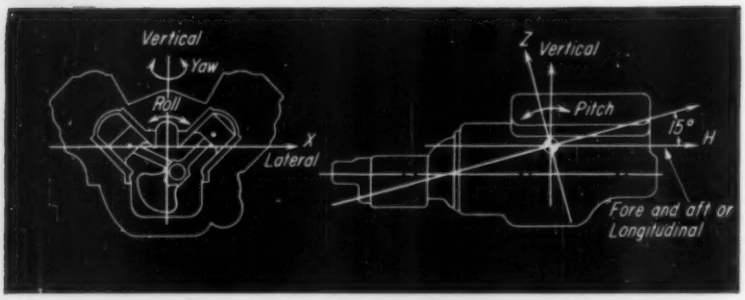
*

Match the Motor to the Job

The traditional approach to the problem of selecting electric motors has been to list all the possible types of motors, including standard and special motors. The equipment engineer or purchaser is then expected to select the type and rating best suited to the application.

Here, a starting point is the types of applications rather than the types of motors. Approximately 80% to 90% of all motor applications can be served by the standard lines of motors, the polyphase and single-phase motors which are normally listed in motor manufacturers' catalogs and stocked by them. The remaining applications involve special motors which cannot be selected readily from a catalog. For these applications the motor manufacturer should be requested to make a study of the mechanical and electrical requirements and advise on the most suitable motors. For specific information on motor application, manufacturers are always ready to work with the designer.

"Match the Motor to the Job," Bruce F. Newman, Sangamo Co. Design Engineering, January 1960, 481 University Ave, Toronto 2, Canada.



From: Dynafacts

ENGINE VIBRATIONS . . . within an internal combustion engine fall into two main classifications: Vibration transmitted to foundation or support structure by engine as a whole, and torsional oscillations induced in crankshaft. Moving parts and periodical variations in gas pressure are causative factors.

FLEXIBLE ENGINE-SUSPENSIONS

Out-of-balance forces in engines, why they should be controlled and how flexible engine-suspensions can solve the problem.

TABLE I—Vibration Modes

Type of Engine	Crank Arrangement	Inertia Forces		Couple or Moment	
		Primary	Secondary	Primary	Secondary
One Cylinder	1	Vertical Horizontal	Vertical	None	None
Two Cylinder Vertical	1·2		Vertical	Pitch Yaw	
Two Cylinder Opposed	1 2 2			Yaw	Yaw
Three Cylinder Vertical	1·2·3			Pitch Yaw	Pitch
Four Cylinder Vertical	1·2·3·4		Vertical		
Four Cylinder Vertical	1 2 3 4			Pitch Yaw	
Six Cylinder Vertical	1·2·3·4·5·6				
Six Cylinder Vertical	1 5 4 3 2 6			Pitch Yaw	

Basis: Equal pistons, equally spaced

Equations of Engine Unbalance:

Vertical inertia force = (Equivalent reciprocating mass) (Vertical acceleration of the piston) plus (Equivalent rotating mass) (Vertical component of crank pin acceleration)

$= (m_{recip} + m_{rotating})\, r\omega^2 \cos\omega t$ plus $(m_{recip})\, r^2/l\omega^2 \cos 2\omega t$

Horizontal inertia force = (Equivalent rotating mass) (Horizontal component of acceleration)

$= (m_{rotating})\, r\omega^2 \sin\omega t$

Basic information obtained from "Diesel Engineering Handbook".

The causes of vibration in an internal-combustion engine are: Unbalance of inertia forces of crankshaft, rods and pistons on engine block resulting in periodic forces and moments; torque reaction due to inertia or cylinder-pressure effects acting on stationary parts about a longitudinal axis.

Effects of these forces vary with the number of cylinders. A one-cylinder engine, for example, has unbalance in all directions in a lateral plane. A six-cylinder engine, which has all its primary and secondary forces and moments balanced, is relatively smooth.

Table I shows the modes of vibration for several types of engines. Only those disturbances caused by rotating and reciprocating parts are considered.

FLEXIBLE MOUNTING

The main objectives in flexibly mounting an internal combustion engine are to:

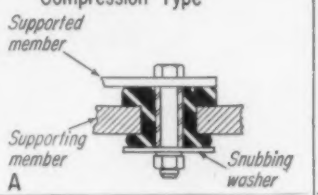
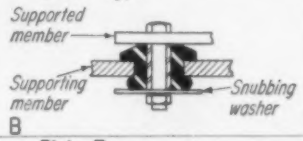
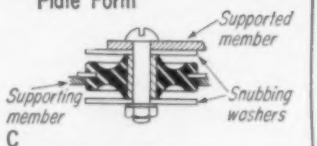
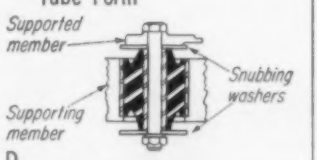
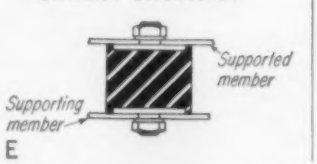
1—Prevent fatigue failure or faulty operation of auxiliary equipment such as radiator cores, relays, instruments, etc.

2—Reduce noise caused by structure-borne engine vibrations.

3—Prevent human discomfort and fatigue caused by transmitted engine vibrations.

Another reason for using flexible engine suspensions is to reduce residual stresses caused by solid mounting. The suspension also accommodates chassis or frame twist without impos-

TABLE II—Elastomeric Mountings Used in Typical Engine Suspensions

Type of Mount	Characteristics
Compression Type  	Rubber in compression provides high shock absorption capacity, exceptional stability, rebound protection, with flexibility to isolate vibration and noise. One-piece construction with flexing element bonded to metal inner member. Standard load ratings from 60 to 900 lb per mounting.
Shear Type  	Same construction as compression-type, but with tapered head to provide softer axial spring rate and allow greater amplitudes. Standard load ratings from 60 to 200 lb per mounting.
Plate Form  	Excellent design to isolate steady-state vibration plus occasional shock. Flexing element bonded between metal outer plate and metal inner member. Standard load ratings from ½ to 310 lb per mounting.
Tube Form  	Axial softness and radial stiffness are achieved by bonding rubber in shear between two concentric metal tubular members. Result is excellent vibration isolation in axial direction with high lateral stability. Standard load ratings from ½ to 1500 lb per mounting.
Sandwich Construction  	Sandwich construction may be loaded in compression to provide high vertical stability and shock protection. Soft radial-spring rate assures good isolation or ateral and torsional disturbances. Standard load ratings from 10 to 2000lb per mounting.

ing high stresses on the engine block and mounting brackets.

APPLICATION

Torsional impulses within an internal combustion engine will cause rotation about the principal longitudinal axis. This axis is inclined upward from rear to front at an angle of 10° to 15°, passing through the center of gravity. For a decoupled system, then, the ideal location for elastomeric mountings is laterally opposite the principal axis.

This arrangement will eliminate forces that result when a rotating unit is not supported at its principal axis. It can provide center-of-gravity support in all planes, assuring a completely decoupled system.

Current engine design seldom permits this ideal arrangement. Front attaching points, for example, are usually near or below the crankshaft centerline. Transmission weight at the rear causes the principal axis to pass in the vicinity of the crankshaft and mounting point. Front mountings should be located higher than rear mountings in order to be opposite the principal axis. However, front mountings are often located in the lower position in truck-engine installation.

Suspension system application approaches the ideal more closely when need for vibration/shock/noise control is pinpointed early in design. At this time, design alterations can be made with minimum expense, standard parts can be used, space for the mounting system can be provided and motion of the system accommodated. The suspension system itself can be incorporated at the lowest cost and with maximum improvement in engine performance.

WHAT ARE THE BENEFITS?

Flexible mounting systems offer the greatest potential for producing smooth, quiet, long-lasting installations for which modern design is striving. Improved operator comfort, reduced stresses in engine and structural components, and protection of sensitive equipment add up to positive advantages.

REFERENCE:

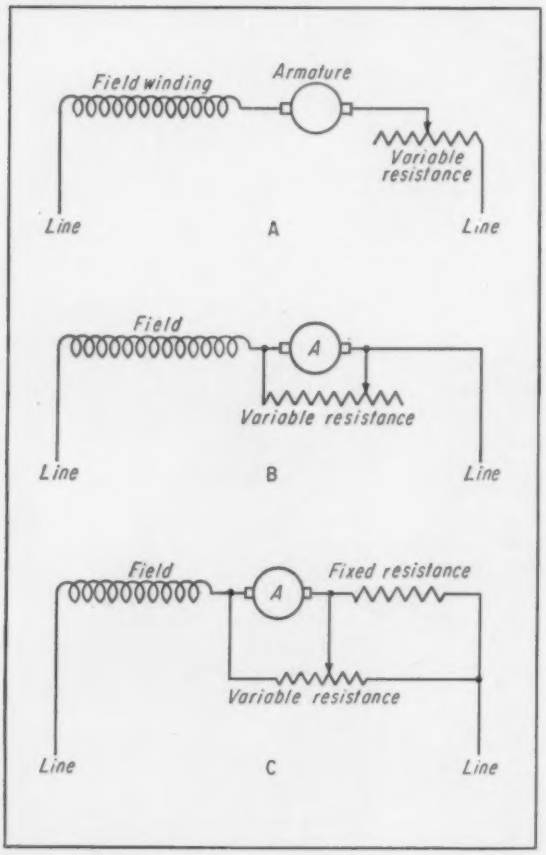
Flexible Engine Suspensions, published in Dynafacts by Lord Mfg. Co, Erie, Pennsylvania, Vol 3, No 2, p 3.

From: Company Bulletin

HOW TO CONTROL SPEED of FHP MOTORS

9 examples of how resistances, capacitors, and electrical governors are best arranged for control of series, shunt and capacitor motors.

For some types of motors, such as standard, synchronous, or induction motors, it is impractical to obtain speed control. In fact, it is their fixed or steady speed under varying loads that makes synchronous and induction motors so ideal for many applications. The speed of such motors can be controlled by changing the frequency of the applied current; this method, however, is not commonly used for fractional horsepower motors.



1—SERIES MOTORS

There are two general types of speed control: Stepless Control with all possible intermediate speeds over a required range; and step-by-step control, which limits control to two or more definite speeds.

SERIES MOTORS

The simplest method of controlling the speed of a series motor is to connect an adjustable resistor in series with the motor, Fig. 1A. The speed for a given load decreases as the control resistance is increased. If enough resistance is added, the motor can be decreased to a standstill, but a reduction in speed of 50% is usually considered the practical limit. In all cases, the speed is highly sensitive to load changes. The slightest increase or decrease in load causes a change in motor speed. This is a characteristic of all series motors, and nothing can be done to prevent it except to use governor control, discussed later. There are many applications, however, in which load conditions are quite uniform at all speeds, and for such applications, the series motor is very satisfactory.

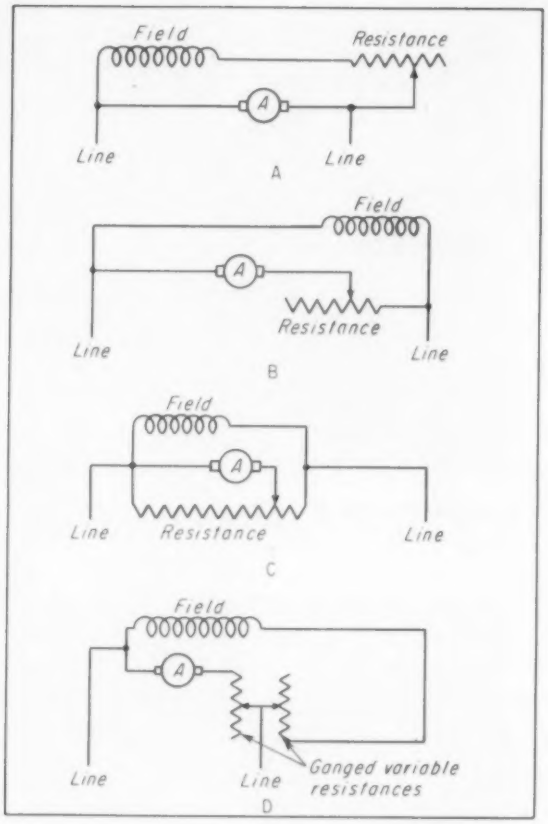
A series motor can also be controlled, Fig. 1B, by shunting an adjustable resistor across the armature. Although the control range is somewhat less, the speed is likely to be more stable, and the starting torque is better because of the stronger field.

Another way to get series motor speed control over a wide range, and still retain reasonable stability at low speeds is to connect a fixed resistor in series with the armature and use a variable resistor across the armature, Fig. 1C.

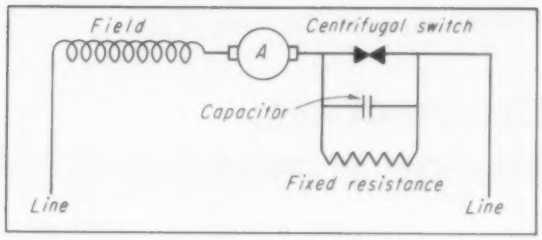
This combination, however, requires an actual test with the proper load to determine the necessary resistance values and wattage ratings of the resistors. If this is not done carefully, the resistors or the field coils may be damaged. Such testing is also needed to assure maximum speed stability.

SHUNT MOTORS

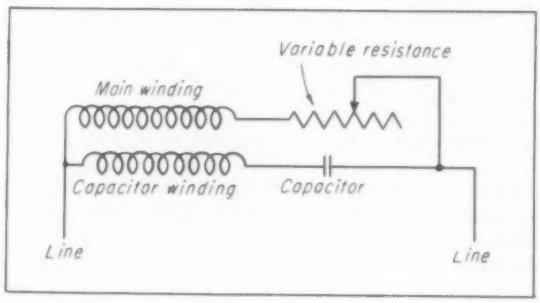
It is common practice to regulate the speed of shunt motors by inserting resistance in the shunt field circuit, Fig. 2A. This weakens the magnetic field which, in turn, speeds up the motor. Such field control provides stable motor speeds at light loads provided the magnetic field is not appreciably weakened. To reduce the speed of a



2—SHUNT MOTORS



3—GOVERNOR-CONTROLLED MOTOR



4—CAPACITOR MOTOR

shunt motor, resistance must be added to the armature circuit, Fig. 2B.

Another way to reduce the speed of a shunt motor is to shunt an adjustable resistor (potentiometer or voltage divider) across the line, Fig. 2C, with one armature lead connected to the movable contactor of the resistor. The movement of the contactor lowers the voltage applied to the armature. By this method, the speed can be brought down fairly low without sacrificing good starting performance. This method, however, dissipates energy continuously in the adjustable resistor and therefore is suited only for small motors and comparatively light loads.

When speed regulation of shunt motor is required over a wide range, adjustable resistors must be used in both the shunt field and armature circuits, Fig. 2D. Weakening the shut field reduces motor starting torque and disturbs speed stability. When resistance is used in the armature circuit, starting torque and speed stability are affected in direct proportion to the added resistance.

GOVERNOR-CONTROLLED MOTORS

For certain fractional horsepower motor applications, usually on series motors but occasionally shunt motors, electric governors, Fig. 3, offer the best solution to speed control problems. The electric governor is a centrifugally operated switch which automatically reduces the current through the motor when it runs faster than the speed for which the governor is set by inserting a resistance in series with the motor. Full line voltage is restored when the speed falls below the setting.

S governors (adjustable during standstill only) are recommended where utmost accuracy in speed adjustment is desired. If a narrow speed range suffices for a job, the adjusted speed can often be held within 5%.

R governors (adjustable during running) provide wide control with speed stability under widely varying loads.

Both types require a small capacitor across the governor contacts to minimize sparking.

CAPACITOR MOTORS

The speed of capicitor motors driving inertia loads can be controlled by inserting resistance in the main winding circuit, Fig. 4.

Shaded pole and split-phase motors with high-resistance rotors can be operated with some reduction in speed by inserting resistance in the stator circuit.

REFERENCE:

Speed Control of Fractional Horsepower Motors. Published by Bodine Electric Co, Chicago 18, Illinois

From: Allis-Chalmers Electrical Review

Correcting Motor Power-factor

Easy-to-make chart provides quick answers to power-factor correction problems for any induction motor.

G. R. BROOKS
Allis-Chalmers Mfg. Co.
Motor-Generator Dept.

Two important power-factor questions can be solved with a compass, straightedge and graph paper: How much capacitance is needed to correct the power factor of an induction motor? What power factor will be obtained with a given capacitor and motor?

Use of the chart requires only motor name-plate and no-load current data. The no-load current can be measured or obtained from the motor manufacturer.

It is assumed that the amount of capacitance used will in no case exceed the no-load motor kva and that the motor does not overspeed when disconnected. If more capacitance is desired or if overspeed should occur, a closer study should be made since it may be necessary to select a capacitor location other than on the motor side of the motor starter.

Draw the quadrant as shown in Fig. 1, then place a dot on the quadrant at its intersection with each horizontal unit line. Draw radial lines from the center of the quadrant to each of these dots and add power-factor values to the chart as shown. The 1% divisions are indicated in like manner.

Capacitor size is in percent of rated motor kva as measured horizontally from full-load power-factor on the quadrant to radial line of power factor as corrected.

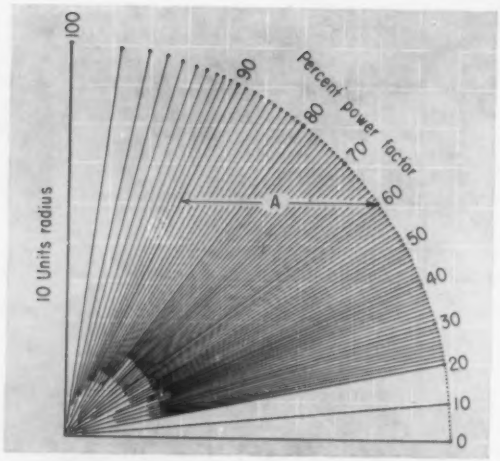
Example

Given a 1000-hp, 2300-volt, 346-amp, 3-phase, 60-cycle, squirrel-cage induction motor with full-load power-factor at 60% and no-load current of 190 amps, how much external capacitance is required to raise power factor to 90%? Let E = phase volts, I = phase amps, m = phases.

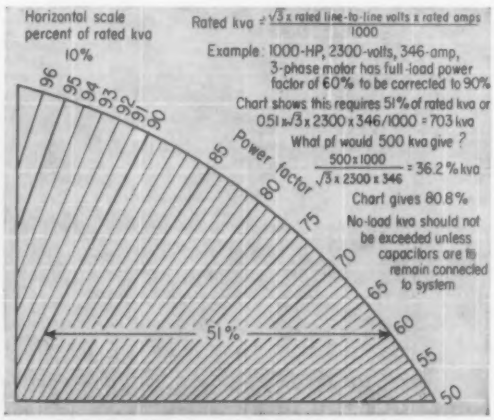
$$\text{No-load kva} = \frac{E \times I \times m}{1000} = \frac{2300}{\sqrt{3}} \times \frac{190 \times 3}{1000} = 757 \text{ kva}$$

$$\text{Full-load kva} = \frac{2300}{\sqrt{3}} \times \frac{346 \times 3}{1000} = 1380 \text{ kva}$$

From the chart in Fig. 2, 51% of full-load kva or $0.51 \times 1380 = 704$ kva of capacitance is required to correct from 60% to 90% power factor.



1—CAPACITOR SIZE obtained from the chart, as shown by line A, is in percent of rated motor kva and is measured from power-factor point to radial line of higher power factor desired.


Horizontal scale percent of rated kva
10%
Rated kva = √3 x rated line-to-line volts x rated amps / 1000
Example: 1000-HP, 2300-volts, 346-amp, 3-phase motor has full-load power factor of 60% to be corrected to 90%
Chart shows this requires 51% of rated kva or 0.51 x √3 x 2300 x 346/1000 = 703 kva
What pf would 500 kva give ?
500 x 1000 / √3 x 2300 x 346 = 36.2 % kva
Chart gives 80.8 %
No-load kva should not be exceeded unless capacitors are to remain connected to system
96
95
94
93
92
91
90
85
80
75
70
65
60
55
50
Power factor
51%

2—ENLARGED PORTION of chart may be used for most power-factor correction problems to obtain greater accuracy.

The 704-kva capacitance does not exceed the 757 kva at no load and can, therefore, be located across the motor terminals with safety if the motor coasts rather than overspeeds when removed from the line.

What power factor will be obtained if a 500-kva capacitor is used instead of the 704-kva rating.

Percent of rated kva = $500/1380 \times 100 = 36.2\%$.

When 36.2% is laid off horizontally from the 60% PF full-load point, 80.8% power factor is obtained.

Once constructed, the chart will apply for any induction motor.

REFERENCE:

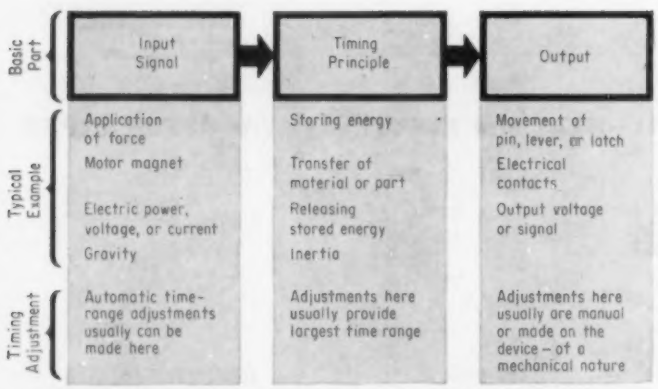
How To Simplify Motor Power-factor Correction by G. R. Brooks, Motor-Generator Dept, Allis-Chalmers Mfg. Co, Milwaukee, Wisconsin. Published in Allis-Chalmers Electrical Review, 3rd Quarter, 1959, p. 27.

From: Westinghouse Engineer

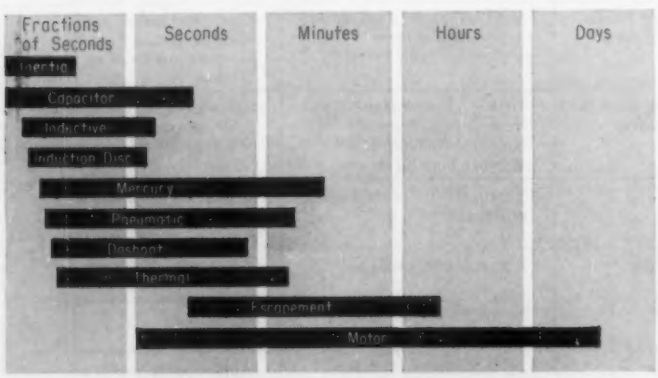
OPERATING PRINCIPLES of 13 TIMING DEVICES

Since most control systems depend on time intervals for operation, the timing device is an essential building block in industrial controls.

JOHN C. PONSTINGL
Engineering Supervisor
Consulting and Application Engineering
Westinghouse Electric Corporation
Cleveland, Ohio



1—BASIC DIVISIONS of operations that are necessary in timing device



2—TIME RANGES for various timing principles. Always evaluate basic needs—a suction cup is as much a timer as an overload relay.

Timing devices serve as delays, sequencers, and programmers in many home electrical appliances and in all phases of automatic and complex industrial and business control systems.

When correctly applied, timing equipment helps achieve safe and consistent operating conditions, better products, and lower process or production costs.

To select the best timing device, the requirements of the application and the basic characteristics of all types of timers must be known. Often, failures occur or results are inadequate because all application factors were not established, or limitations of the timing device were not known.

WHAT IS A TIMER?

A timer is a device that produces an output after receiving an input signal; the time interval between the input and output, of course, can be controlled. Three ingredients are essential to a timer: a timing method, an input to start or sustain the timing period, and an output, Fig. 1. A manual input signal, for example, could be the setting of a stove timer dial. An electric input signal could be used to energize or de-energize an electromagnet, motor, or circuit of a timing device. At the end of the time

interval, a mechanical device moves or electrical contacts make or break to produce an output.

BASIC GROUPS

Timer operating principles can be divided into three groups: Material transfer, heat transfer, and electrical transfer.

The material transfer principle is merely the age-old hour-glass concept, where a metered quantity of material is transferred from one location to another in a restricted manner. Pneumatic, mercury, dashpot,[6] and motor timers all fit in this category. For instance, the gear train of a motor timer is a metered quantity (X number of gear teeth must be moved in a certain time period).

In the heat transfer system, heat is transferred from an electrical heater to a metallic element. As heat is absorbed, the metal stretches, bends as in a bimetal, or melts as in a solder-pot relay, closing or opening an electrical contact. Thermal timers frequently are used on automobile-turn signals as well as in motor-protective devices. Various methods are used to transfer heat to the "heat motor" or metal element. Often, the heat is generated within the metal element, as in the case of flasher timers. This minimizes the effect of ambient temperatures.

The electrical transfer principle (sometimes called energy storage) is an extremely flexible source of timing, and is especially suited for use in static controls. Inductive timers and capacitor-discharge or charge schemes are the more common types of electrical transfer timers.

Any phenomenon that depends on "time" may have merit as a timing device. The suction-cup timer used in roll-towel racks is an example of an inexpensive timer solution for a commercial product.

This article has presented basic principles; the designer's task is to embody these in simple, low-cost devices.

REFERENCE:

Timing Devices—Essential to Automation by John C. Ponstingl, Engineering Supervisor, Consulting and Application Engineering, Westinghouse Electric Corp, Cleveland, Ohio. Published in Westinghouse Engineer, Sept '59, p. 152.

TABLE I—MATERIAL TRANSFER TYPES

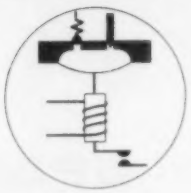
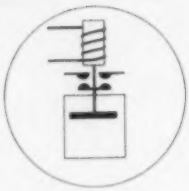
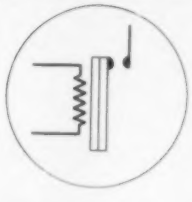
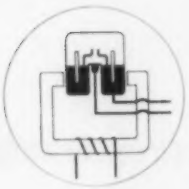
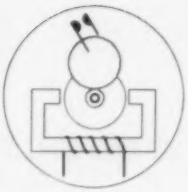
TYPE OF TIMING DEVICE	 PNEUMATIC	 DASHPOT
Input (initiates timing period)	Voltage — solenoid forces diaphragm to expel air from chamber	Voltage — solenoid moves piston
Motivating Force (sustains time period)	Bias spring moves diaphragm and pulls air into chamber. Time is a function of spring force	Voltage — moves piston. Time is inverse function of voltage
Restricting Media (controls time period)	Needle valve. Time is inverse function of orifice size	Time is inverse function of clearance and orifice size and direct function of distance piston moves
Output	Contacts — by diaphragm movement	Contacts — by piston movement
Time Range	0.2 to 200 seconds	1 to 60 seconds
Accuracy	±10%	±20%
Reset Time	Instantaneous — with check valve	Instantaneous — with check valve

TABLE II—HEAT and ELECTRICAL TRANSFER TYPES

TYPE OF TIMING DEVICE	 THERMAL	INDUCTIVE DECAY
Input (initiates timing period)	Voltage — applied to heater element. Time is inverse function of voltage	Voltage — removed from coil
Motivating Force (sustains time period)	Metal expands or moves with application of heat	Gravity or spring pulls relay armature. Time is inverse function of spring tension
Restricting Media (controls time period)	Timing is function of heat transfer rate, thermal capacity of metal, and distance bimetal moves	Inductance delays decay of flux. Copper rings increase inductance and time delay
Output	Contacts — by heated metal or bimetal	Contacts — by armature movement
Time Range	0.5 second to 5 minutes	0.5 to 3 seconds
Accuracy	±50%	±5%
Reset Time	Up to 2 minutes	Approximately 10% of time period



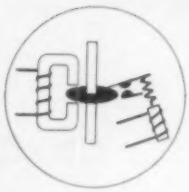
MERCURY
Voltage — pulls solenoid into mercury
Mercury forces gas from bell through porous ceramic or orifice
Porous ceramic or orifice. Time is inverse function of gas leakage
Mercury completes circuit
0.2 second to 20 minutes
Fair
Instantaneous



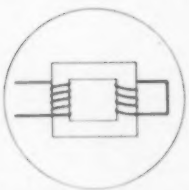
MOTOR
Voltage — starts clock motor
Clock motor drives gear train or cam shafts
Speed of clock motor and gear ratio of gear train. Time is function of distance contact or cam must move
Contacts — by gear train movement
1 second to days
0.1 second for synchronous motor. About 5% for dc motor
Instantaneous — with release-clutch or ratchet

ESCAPEMENT
Voltage — applied to solenoid. On manual device, spring is wound
Solenoid plunger moves. Time is inverse function of voltage and resulting pull
Escapement and inertia wheel moves solenoid plunger. Time is function of oscillating period
Contacts — by plunger movement
1 to 6 sec for magnetic — hrs for manual
Magnetic — ±15% Manual — 1 sec
Instantaneous — with ratchet release

INERTIA
Voltage — applied to relay coil
Voltage — applied to relay coil
Large mass on armature delays movement
Contacts — by armature movement
0.1 second or less
±10%
Same as time period

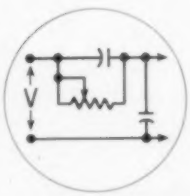


INDUCTION DISC
Voltage — applied to drag magnet
Separate magnet armature biases spring which rotates disc. Time is inverse function of spring pull
Disc rotation slowed by drag magnetic field. Time is function of distance between contacts
Contacts — by disc rotation
1/6 second to 5 seconds
±10%
0.1 second

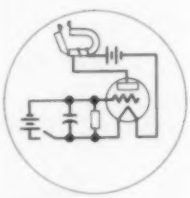


INDUCTIVE BUILDUP
Voltage — applied to winding on magnet core
Magnetic flux
Inductance of magnetic circuit delays buildup or change in flux
Voltage — by flux buildup
1 second maximum
±5%
Same as time period

CAPACITOR DISCHARGE
Voltage — disconnected. Time is function of voltage and capacitor size
Energy stored in capacitor. Time period is direct function of capacitor size
Shunting resistor adjusts capacitor discharge. Time is direct function of resistance value
Voltage. Or contacts by adding relay
0.1 to 30 seconds
±5% depends on device sensing output voltage
10% or less of time period, depending on charge circuitry



CAPACITOR CHARGE
Voltage charges capacitor. Time is function of voltage and capacitor size
Charging voltage. Time is direct function of voltage and capacitor size
Charging rate determines time
Voltage—by capacitor charge
0.2 to 20 seconds
±5%
10% of time period



ELECTRONIC
Same as capacitor discharge
Same as capacitor discharge
Same as capacitor discharge
Voltage—amplified by electronic tube
0.01 to 30 seconds
±1%
10% of time period

From: Sperry Engineering Review

5 Clutches for Servomechanisms

Described are: Friction-disc, hysteresis, eddy-current, magnetic particle, and magnetic-fluid clutches.

KENNETH W. KOHLMEYER
Advanced Studies Engineering Department
Surface Armament Division
Sperry Gyroscope Company

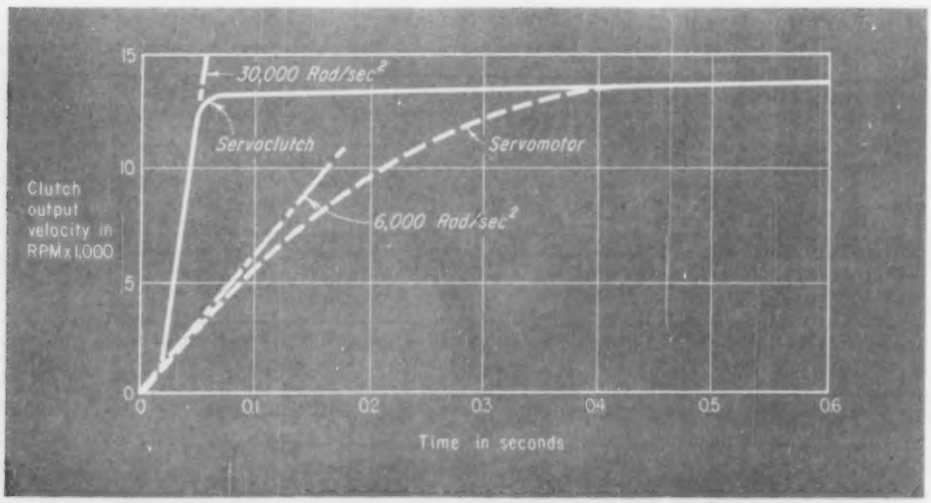
For a great many years the clutch has played an important role in the automotive industry and in the design of industrial machinery. In the past 15 years, new and wider applications of the familiar clutch have been found as a result of the tremendous advances in the automatic controls field.

Five categories of clutches are available at the present time that can be used for servo application, and several additional types are still in the development stage. The most familiar types are friction-disc, hysteresis, eddy-current, magnetic-particle, and magnetic fluid.

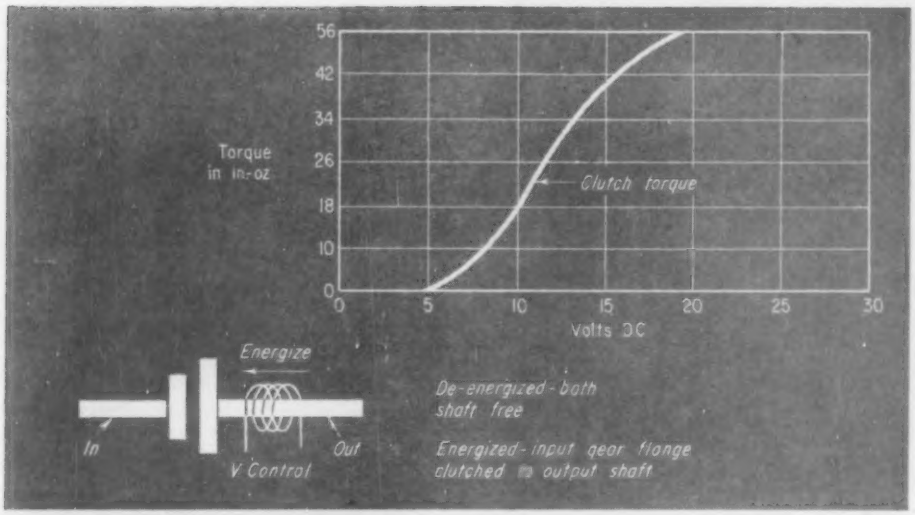
FRICTION-DISC

The friction-disc clutch is, perhaps, the most widely used. A conventional type consists of a stationary field, which when energized by the control current, electromagnetically couples the input disc (drive motor side) to the output disc (load side). One disadvantage inherent in this method of torque transmission is disc wear due to the physical contact of the disc surfaces. This factor can be minimized by designing the system so that a minimum amount of slippage occurs in the clutch. In addition, clutch manufacturers have increased the life of the disc by case hardening and chrome plating. The advantages of this clutch are its high ratio of output torque to control power, light weight, and compactness.

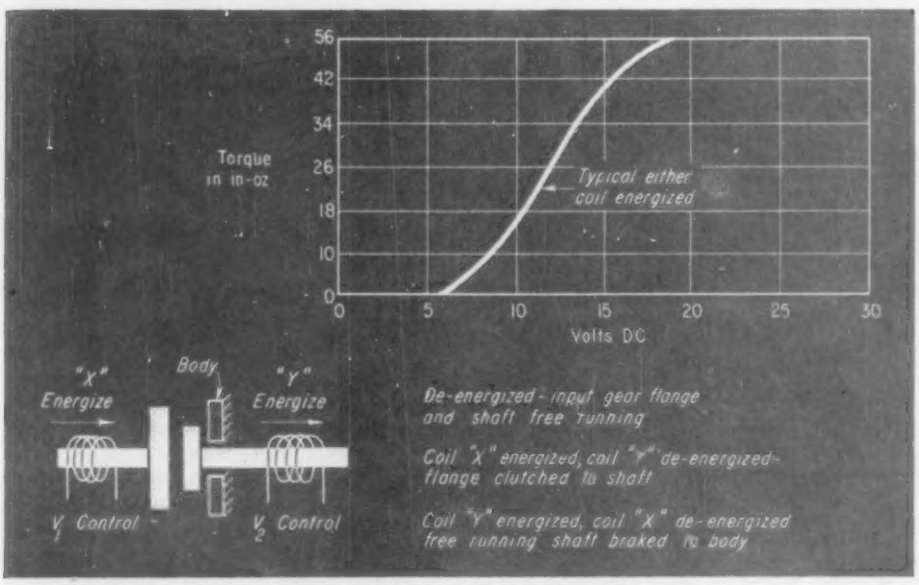
The friction-disc clutch is most applicable in instrument servos where high accelerations are desired, or for special applications. However, it can be used in systems having power requirements of several hundred watts. It is in-



1. ACCELERATION CHARACTERISTICS of a clutch actuator and a typical instrument servomotor, showing a potential advantage of clutch operation.



2. SIMPLIFIED SCHEMATIC DIAGRAM of a friction-disc clutch and a curve of its dynamic characteristics.



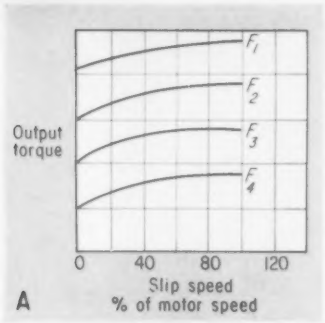
3. Friction-disc clutch and brake combination is described, showing both the schematic and the performance curve when either one of the coils is energized.

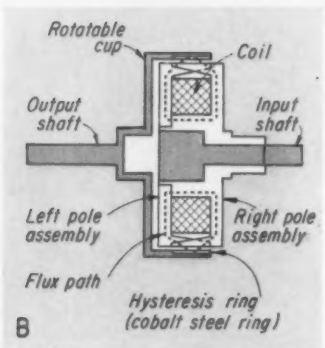
herently a nonlinear, on-off device, but it can be linearized by dithering. Linear operation is not desirable, however, because the life of the disc is reduced by the constant chattering. Figs. 2 and 3 show the physical and performance characteristics of a friction-disc clutch and clutch-brake combination.

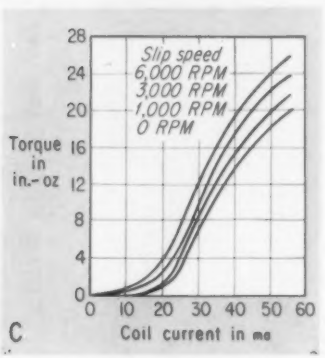
HYSTERESIS

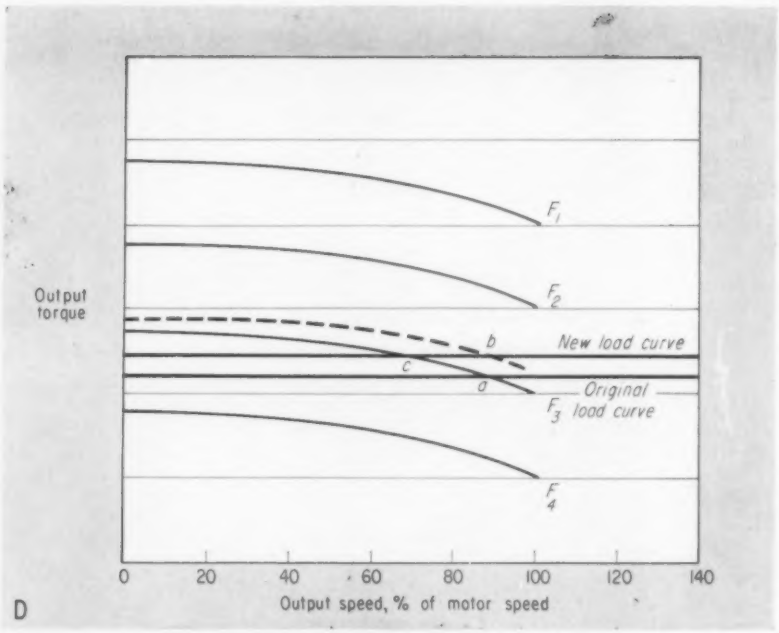
Hysteresis clutches operate on the same basic principle as hysteresis motors. The member coupled to the drive motor—input side of the clutch—consists of overlapping pole assemblies and an exciting coil. A constant dc excitation is supplied to the coil through brushes and slip rings. The member coupled to the load—output side of clutch—consists of an aluminum or copper cup lined with a permanent magnet ring made of hardened cobalt steel. The cup is integral with the output shaft and is free to rotate around the pole assembly. When the pole structure is driven by a motor, the steel ring will follow the poles. A torque is created because the hysteresis component of the permanent magnet field is in quadrature with the inducing field. The torque transmitted is a function of control, or excitation, current.

Some disadvantages of the hysteresis clutch are its large size for its torque-producing capability, its low gain, and its limitation to very low power systems. The advantages









4. Typical hysteresis clutch characteristics are given here. Torque-slip curves are shown (A) for varying coil excitation; (B) shows physical construction; torque vs output speed curves (C) are for various excitation levels; curves (D) given values of torque vs coil excitation.

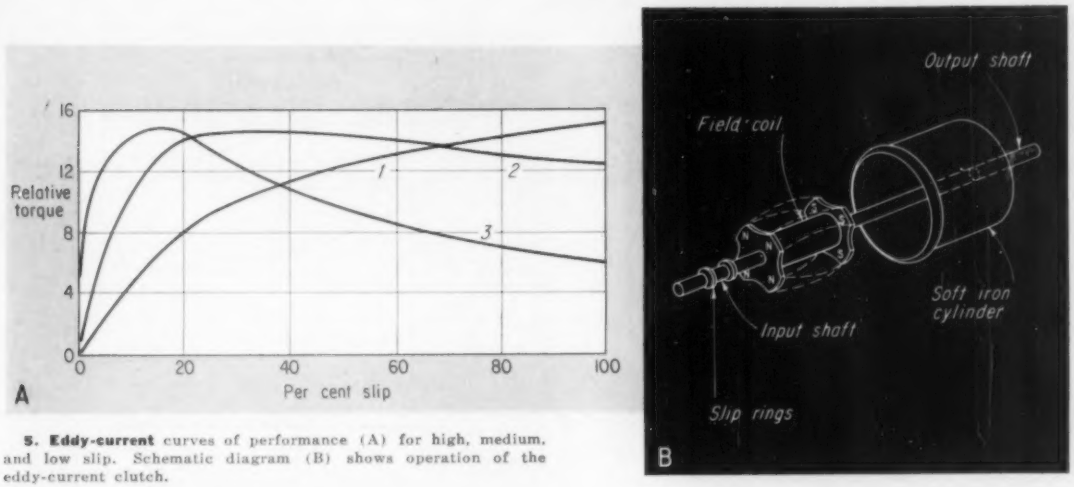
of this type of clutch include excellent reliability, repeatability and linearity, and smooth transmission with minimum drag torque.

Because of the inherent linearity, the clutch is readily adaptable to continuous-control systems. It is best suited for use in low power instrument servos requiring wide-range speed control and high accelerations. The clutch can be driven by the push-pull output stage of a conventional servo amplifier. Two clutches operated in this manner provide a system having no backlash. Characteristics of a typical hysteresis clutch are shown in Fig. 4.

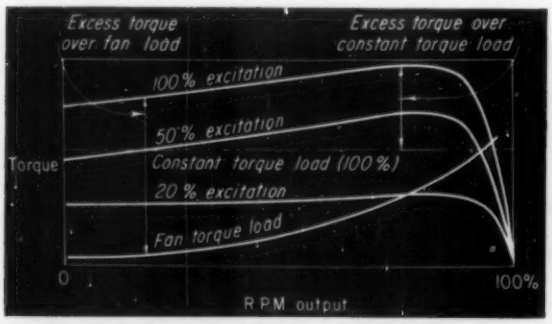
EDDY-CURRENT

Eddy-current clutches operate on the same basic principle as induction motors. The input member consists of an electromagnetic yoke which is driven at a constant speed by the drive motor. A metal disc is mounted on the output member which is connected to the load. When the electromagnetic yoke is energized by the control signal, eddy currents are induced in the metal disc as a result of the relative motion between the yoke and the disc. Coupling between the input and output shafts results from the electromagnetic forces set up between the eddy currents in the disc and the magnetic field of the yoke. Unlike the clutches described previously, the amount of torque transmitted by the eddy-current clutch is proportional to the ratio of input to output shaft speeds (slip). Maximum torque transfer occurs when the speed of the output shaft is one half the speed of the input shaft. The magnitude of slip is proportional to the magnetic field, which in turn is proportional to the control current. Fig. 5 shows the characteristics of this type of clutch.

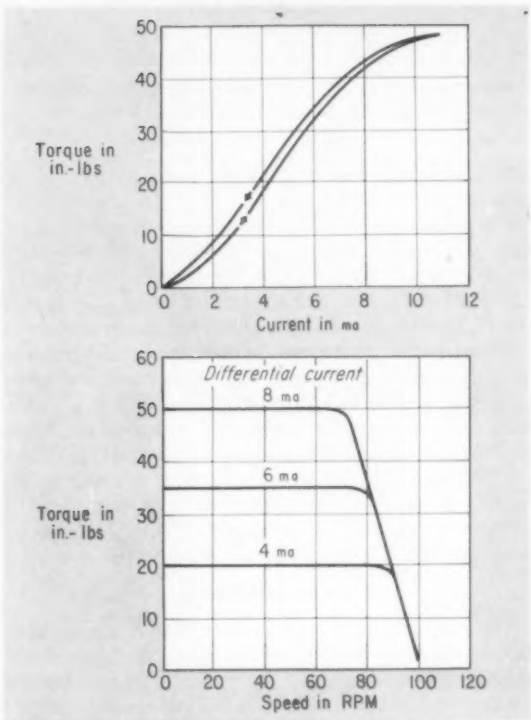
The major disadvantage of this type of clutch is the power loss resulting from slipping. When used in a system requiring a wide range of speed control and high starting torque, the clutch suffers a reduction in efficiency, as shown in Fig. 6. Some advantages of the eddy-current clutch are: Smooth control at all speeds; extreme reliability because no commutators or brushes are required; applicability over a very wide power range from instrument servos



5. Eddy-current curves of performance (A) for high, medium, and low slip. Schematic diagram (B) shows operation of the eddy-current clutch.



6. Speed-torque relationship for typical eddy-current coupling at various levels of excitation. This type can easily be made linear.



7. Torque-current, torque-speed curves for a typical magnetic-particle clutch.

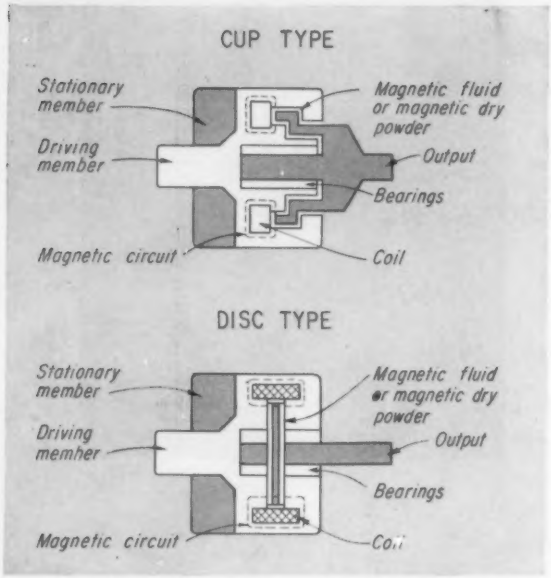
to systems requiring thousands of horsepower; inherently linear characteristics, making it ideal for continuous-control applications; no r-f noise generation.

A closed-loop system employing the eddy-current clutch has been designed for positioning a 250-foot reflector in azimuth and elevation with a static accuracy of ±0.3 milliradian. The power required to drive the antenna (at a maximum tracking rate of 20 degrees per minute with a 45 mph wind load) is 110 hp.

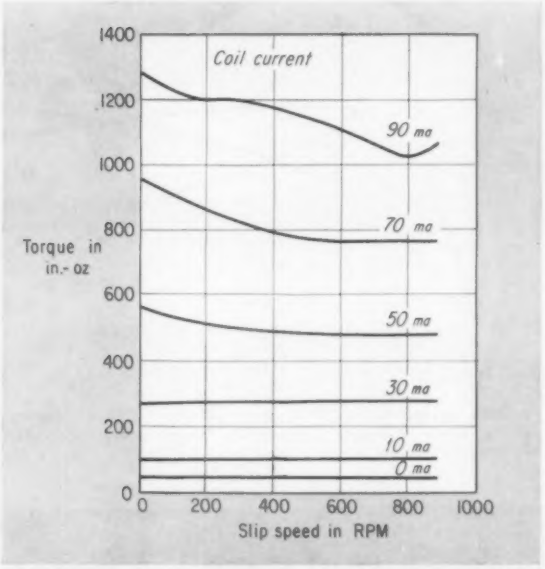
MAGNETIC-PARTICLE

Torque transmission is achieved in this type of clutch by placing a dry mixture of magnetic particles in the gap between two discs. When the clutch is energized by a direct current, the particles become a magnetic link, coupling the input and output members. The shear strength of the bond is proportional to the control current. Provided there is no saturation of the particles, the relation of torque output to control current is a linear function except in the area of zero excitation. This nonlinear region can be minimized by employing a push-pull clutch arrangement.

Some disadvantages of this type of clutch are poor heat dissipation, binding (due to the concentration of iron particles as a result of centrifugal force), corrosion, and wear. However, the problems of corrosion, binding, and wear have been minimized by improving the magnetic particle mixture. The heat dissipation deficiency limits the clutch somewhat for continuous-control operation. The magnetic-particle clutch wears better than the friction-disc clutch but not nearly as well as the eddy-current or



8. Basic designs for either dry- or fluid-particle clutches.



9. Torque-slip curves for magnetic-fluid clutch.

hysteresis types. Fig. 7 gives the characteristics of the magnetic-particle clutch.

The advantages of this clutch are smooth speed control, high power-gain (approximately 200), and very high torque-to-inertia ratio. As in the friction-disc type, the magnetic-particle clutch lends itself to dual operation in a small, lightweight package suitable for instrument servos.

Although this clutch can be used in systems requiring up to 200 watts, it is primarily used in small, low power instrument servos requiring very high response. Some other applications are in low-inertia absorption dynamometers, brakes, disconnects, variable-torque-limiting devices, and tension devices. However, when considering this clutch for servo application the designer must keep in mind that the clutch is designed primarily for intermittent loads and not for continuous slipping.

MAGNETIC-FLUID

The magnetic-fluid clutch is similar to the dry magnetic-particle clutch in principle of operation, operating characteristics, and application. The major difference between the two clutches is that in the fluid clutch the particles are suspended in oil. Characteristics of the fluid type are presented in Fig. 9.

A comparison of the two clutches shows that the fluid clutch has the following undesirable characteristics: Leakage at high temperature operation, breakdown of oil at high temperatures, and settling of the particles during extended periods of storage. The fluid clutch has the same advantages as the dry clutch and in addition exhibits superiority in several other characteristics: Smoother operation, more uniform distribution of particles during operation, less residual drag, superior cooling capability, corrosion resistance, continuous lubrication, and good wearing characteristics.

Application of the fluid clutch in a closed-loop continuous-control system is limited by the amount of slippage required. For high-slip operating, artificial cooling may be required to aid in the heat dissipation.

This type of clutch servo is presently employed in the "Stratoscope" project sponsored by the Office of Naval Research. The servos are used in the azimuth and elevation drives of a balloon-borne device which keeps a telescope pointed at the sun.

It is evident from the foregoing discussion of various types of clutches that the controls engineer must consider a number of factors before making a selection. The most important to be considered are duty cycle, power requirements, linear or nonlinear control, slipping and heat dissipation, and desired servo response. For a very high response, nonlinear, low power, minimum-slippage instrument servo, the friction-disc, dry-particle, or fluid-particle clutches are most applicable. For linear operation of a similar system, a hysteresis clutch is more suitable. Linear operation in the medium and high power ranges can be accomplished by employing the eddy-current clutch.

To date, the application of clutch servos has by no means been explored to the fullest extent, especially in the medium and high power ranges. There can be little doubt that the increasing interest in these devices at present will be reflected in greatly expanded application in the near future.

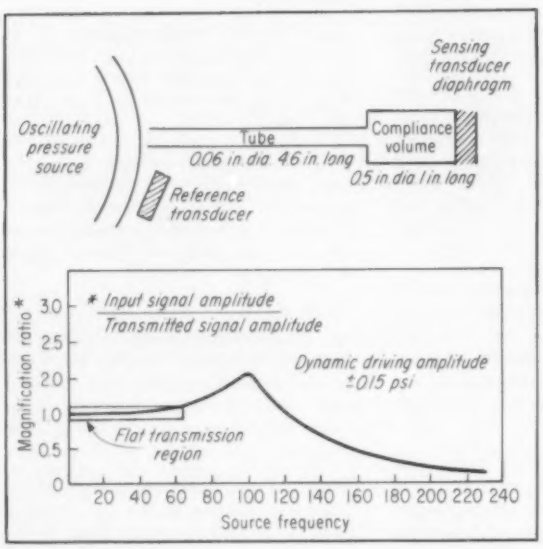
REFERENCES

Clutch Servomechanisms Design and Applications by Kenneth W. Kohlmeyer, Advanced Studies Engineering Department, Surface Armament Division, Sperry Gyroscope Company, Great Neck, New York. Published in Sperry Engineering Review, June 1959, p. 10.

DYNAMIC RESPONSE OF REMOTE PRESSURE PICKUPS

ROBERT J. REID
EDWARD M. KOPS
Convair

How interconnecting tubing and transducer-chamber volume can effect accuracy in pneumatic transmission of oscillating pressure.

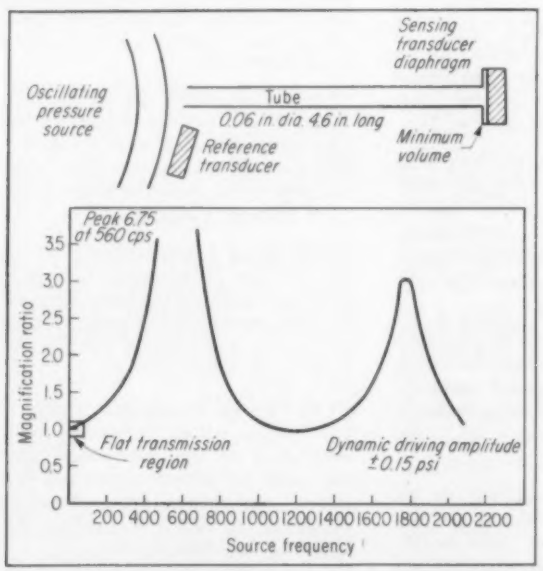


Remote sensing of pressures is often necessary. The connecting transmission system, however, introduces resonance problems—the air rushing back and forth in the tube has the characteristics of mass, while the enclosed compliance volume at the end of the tube is analogous to a spring. Roughness of the tube walls, impedes flow in the tube and uses energy, thereby providing viscous damping to the pneumatic resonant system.

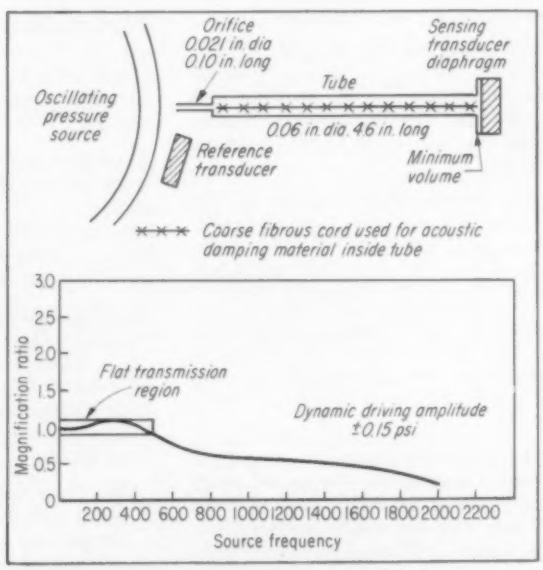
The diagrams presented here show the effect, on range and accuracy of signal transmission, of changing the compliance volume and tube diameters of the pneumatic sensing system.

REFERENCE:
Dynamic Response of Remote Pressure Pickups by Robert J. Reid and Edward M. Kops, Convair, San Diego, California. Published in Instruments & Control Systems, August 1959, p. 1202.

1—CONNECTING TUBE and volume chamber for remote transducer, and typical frequency-response characteristic. Resonance effect is due primarily to connecting tubing and the compliance volume.



2—MINIMUM-VOLUME TRANSDUCER CHAMBER and its effect on frequency-response characteristic. The flat transmission region is short and resonance occurs at 560 cps.



3—REDUCING TUBE DIAMETER at the test chamber and inserting a fibrous cord for damping combine to produce the improved frequency-response characteristic shown.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(H-1) Flexible Control Cables—Bulletin, 4 pp. Describes standard control assemblies and special purpose heads. Illustrates applications; presents design data. American Chain & Cable Co, Inc, 601 Stephenson Bldg, Detroit 2, Mich.

(H-2) Electromagnetic Control—Catalog, 180 pp. Provides circuit diagrams, dimensions, operating characteristics for automatic transfer switches, remote control switches, contactors, relays, solenoids, and electric plant controls for engine starting, battery charging and other functions. Automatic Switch Co, 50-56 Hanover Rd, Florham Park, NJ.

(H-3) Diaphragms—Catalog, 24 pp. Explains how to design for diaphragm made to always be in relaxed position. Gives sizes, characteristics. Bellofram Corp, Blanchard Rd, Burlington, Mass.

(H-4) Fractional Hp Motors—Bulletin, 12 pp. Lists sizes, ratings, types and dimensions of 300 motors. Bodine Electric Co, 2500 W Bradley Pl, Chicago 18.

(H-5) Timers—Catalog, 20 pp. Describes synchronous timing motors, interval timer, time delay relay, program timers and others for control or display. Cramer Controls Corp, Centerbrook, Conn.

(H-6) Limit Switches—Brochure, 12 pp. Provides construction details, operating data for oil-tight, ac or dc types with several methods of actuation. Cutler-Hammer, Inc, 315 N 12 St, Milwaukee, Wisc.

(H-7) Electric Motors—Bulletin, 14 pp. Motor sizes run from 1/12 to 15 hp. Some types are: 3, 2 and single phase, explosion proof, drip proof, fan-cooled. Doerr Electric Corp, Cedarburg, Wisc.

(H-8) Industrial Counters—Catalog, 8 pp. Presents specifications for electrical, lineal, stroke types and accessories. Durant Mfg Co, 1938 N Buffum St, Milwaukee 1, Wisc.

(H-9) Instrument Counters—Catalog, 8 pp. Provides dimensioned drawing and design considerations for rotary drive counters. Durant Mfg Co, 1938 N Buffum St, Milwaukee 1, Wisc.

(H-10) Thermostats—Catalog, 8 pp. Describes strut and tube differential expansion type in ranges from —100 to +1500F. Fenwal, Inc, Pleasant St, Ashland, Mass.

(H-11) Cams—Catalog, 7 pp. Gives stroke curves and load capacities for standard plate and groove types. Mentions other special designs. Ferguson Machine Corp of Ind, 7818 Maplewood Industrial Court, St. Louis.

(H-12) Motor Controls—Catalog, 72 pp. Describes magnetic starters and contactors, push buttons, drum controllers, foot switches, pressure switches as well as related pilot devices. Includes ratings and prices. Furnas Electric Co, 1050 McKee St, Batavia, Ill.

(H-13) Miniature Fhp Motors—Catalog, 100 pp. Gives dimensioned drawings, characteristics curves of ac and dc motors, blowers, fans, vibrators, generators, gyros, actuators, timers and specialized motorized devices. Globe Industries, Inc, 1784 Stanley Ave, Dayton, Ohio.

(H-14) Fhp Motors—Catalog, 8 pp. Presents ac-dc, shaded pole, induction and gear motors, motor blowers. Ratings range from 1/2000 to 1 hp. Howard Industries, Inc, 1760 State St, Racine, Wisc.

(H-15) Fhp Motors—Catalog, 59 pp. Provides specifications and drawings for dc, shaded pole, induction and gear motors plus blowers and bases. Howard Industries Inc, 1760 State St, Racine, Wisc.

(H-16) Proximity Switch—Brochure, 4 pp. Gives operating characteristics and dimensions of switch which detects magnetic materials without contact. Micro Switch, Div of Minneapolis-Honeywell Regulator Co, Chicago at Spring Sts, Freeport, Ill.

(H-17) Machine Controls—Catalog, 16 pp. Describes components and their combination in electric control systems for manual operation of industrial power machinery. Micro Switch, Div of Minneapolis-Honeywell Regulator Co, Chicago at Spring Sts, Freeport, Ill.

(H-18) Limit Switches—Catalog, 20 pp. Describes various heavy duty types such as oil-tight and explosion proof designs. Micro Switch, Div of Minneapolis-Honeywell Regulator Co, Chicago at Spring Sts, Freeport, Ill.

(H-19) Control Switches—Catalog, 10 pp. Describes such switches as multi-pole rotary and push-pull types. Some suitable for military equipment. Joseph Pollak Corp, 85 Freeport St, Boston 22.

(H-20) Weatherproof Motors—Brochure, 4 pp. Internal protection makes open 1 to 125 hp ac motors safe against moisture, dirt. Reliance Electric & Engineering Co, 24701 Euclid Ave, Cleveland 17.

(H-21) Fhp Ac Motors—Bulletin, 8 pp. Describes four types of motors in four frame sizes. Ratings are from 1/100 to 1/3 hp. Robbins & Myers, Inc, Fractional Motor Div, 1345 Lagonda Ave, Springfield, Ohio.

(H-22) Control Cables—Catalog, 7 pp. Presents dimensioned drawings and specifications of push-pull types. Southwest Products Co, 1705 S Mountain Ave, Monrovia, Cal.

(H-23) Thermostats—Bulletin, 4 pp. Presents illustrations and specifications of bimetal thermostats applicable in industry, appliances, electronics equipment. Stevens Mfg Co, Inc, Box 1007 Annex, Mansfield, Ohio.

(H-24) Precision Switches—Data folder, 19 pp. Provides data on snap-action switches with several types of actuators. Waterproof, hermetically sealed, high temperature, subminiature, rotary designs shown. Texas Instruments, Inc, Metals & Controls Div, 72 Forest St, Attelboro, Mass.

(H-25) Motor Controls—Catalog, 49 pp. Furnishes selection guides and specifications for inherent overheat motor protectors, starting relays, winding thermostats and circuit breakers. Texas Instruments, Inc, Metals & Controls Div, 72 Forest St, Attleboro, Mass.

(H-26) Commercial Thermostats—Data folder, 8 pp. Describes adjustable tube type thermostats plus assemblies used in appliances and cooking equipment. Texas Instruments, Inc, Metals & Controls Div, 72 N Main St, Versailles, Ky.

(H-27) Circuit Breakers—Catalog, 35 pp. Contains data on commercial and precision types, including miniature, subminiature and microminiature designs. Texas Instruments, Inc, Metals & Controls Div, 72 Forest St, Attleboro, Mass.

(H-28) Precision Thermostats—Catalog, 28 pp. Provides settings, dimensions, other information on fixed temperature small thermostats for aircraft missiles and electronics. Also thermal valves. Texas Instruments, Inc, Metals & Controls Div, 72 Forest St, Attleboro, Mass.

(H-29) Thermostats—Catalog, 24 pp. Describes fixed setting, snap-action, disc type

thermostats for air conditioning, refrigeration and appliances. Texas Instruments, Inc, Metals & Controls Div, 72 N Main St, Versailles, Ky.

(H-30) Solenoid Devices—Catalog, 50 pp. Describes solenoids, solenoid operated brakes; and reciprocating motors with unlimited stroke and pull. Trombetta Solenoid Corp, 329 N Milwaukee St, Milwaukee, Wisc.

(H-31) Temperature Controls—Catalog, 26 pp. Gives illustrations, dimensions, characteristics of complete thermostats and thermal time delay relays. Also includes components. George Ulanet Co, 413 Market St, Newark, NJ.

(H-32) Temperature Controls—Catalog, 8 pp. Presents illustrations, tables of specifications, optional features for remote and locally mounted types in range of —150F to 1000F. United Electric Controls Co, 85 School St, Watertown 72, Mass.

(H-33) Pressure Controls—Catalog, 8 pp. Presents illustrations, tables of specifications, special options in 8 types with ranges from 30 in. Hg vacuum to 1700 psi. United Electric Controls Co, 85 School St, Watertown 72, Mass.

(H-34) Quiet Motors—Bulletin, 4 pp. Resilient mountings of 1/6 to 10 hp motors fit them for applications where silence is desired. Wagner Electric Corp, 6400 Plymouth Ave, St. Louis 33.

(H-35) Engines, Industrial and Agricultural—Brochure, 6 pp. Describes line of 4-cylinder engines. Includes power curves, engine details, and installation dimensions of self-contained power units. Industrial Engine Dept, Willys Motors, Inc, Administration Bldg, Toledo, Ohio.

(H-36) Air-cooled Engines—Bulletin, 4 pp. Provides power curves and construction details for one, two and four cylinder models from 6 to 56.5 hp. Wisconsin Motor Corp, 1910 S 53 St, Milwaukee 46.

(H-37) Timers and Relays—Catalog, 27 pp. Describes automatic reset, cycling and sequence timers; single pole, double pole and twin circuit time switches; flashers and relays. Aemco, Inc, 10 State St, Mankato, Minn.

(H-38) Rocket Engines—Bulletin, 4 pp. Describes standby engines of 250 lb and 1000 lb thrust for civil aircraft. Aerojet-General Corp, 6352 N Irwindale Ave, Azusa, Cal.

(H-39) Motor Controls—Catalog, 48 pp. Describes motor starters and control components such as relays, switches. Allen-Bradley Co, 136 W Greenfield Ave, Milwaukee 4.

(H-40) Dc Generators and Motors—Bulletin, 6 pp. Describes construction, performance, dimensions and available modifications. Motor ratings, one to 200 hp. Generator ratings, ¾ to 170 kw. The Louis Allis Co, 427 E Stewart St, Milwaukee, Wisc.

(H-41) Control Switches—Bulletin, 8 pp. Gives general details for standard and mill duty switches for instruments and controls. Allis-Chalmers Mfg Co, Box 512, Milwaukee 1.

(H-42) Diesel Generator Sets—Brochure, 4 pp. Provides specifications for diesel engines from 10 to 28 hp, generators from ½ to 100 kw. American Marc, Inc, 1601 W Florence Ave, Inglewood, Cal.

(H-43) Engine and Compressor Controls—Catalog, 6 pp. Describes temperature and pressure sensitive valves and switches for control and protection. Amot Controls Corp, Box 1707, Richmond, Cal.

(H-44) Motor Controls—Catalog, 78 pp. Furnishes wiring diagrams, dimensions, other data for many kinds of starters, contactors, relays, switches, pushbutton stations and accessories. Industrial Control Div, The Arrow-Hart & Hegeman Electric Co, 103 Hawthorn St, Hartford, Conn.

(H-45) Automation Components—Catalog, 24 pp. Describes timers, counters, circuit cam timers, other components and packaged control systems. Automatic Timing & Controls, Inc, King of Prussia, Pa.

(H-46) Gas Turbines—Brochure, 26 pp. Describes two turboshaft and one turboprop version of the T-53 engine. Military power ratings are from 901 to 943 eshp. Lycoming Div, Avco Corp, 550 S Main St, Stratford, Conn.

(H-47) 2000 Hp Gas Turbines—Brochure, 18 pp. Describes two turboprop and two turboshaft versions of the T-55 engine. Military ratings go from 1532 to 2036 eshp. Lycoming Div, Avco Corp, 550 S Main St, Stratford, Conn.

(H-48) Millivolt Meter—Brochure, 4 pp. Meter reads transducer output voltage by tape imbedded slidewire potentionmeter; gives digital readout. Attachments give added flexibility. B & H Instrument Co, Inc, 3479 W Vickery Blvd, Fort Worth, Texas.

(H-49) Pressure Sensing Elements—Bulletin, 8 pp. Presents spring rates, pressure ranges, dimensions of capsules which make up the complete element. End fittings and spacers also shown. The Bristol Co, Waterbury 20, Conn.

(H-50) Temperature Controls—Catalog, 4 pp. Describes differential expansion type controls and limit switches for temperatures to 2000F. Burling Instrument Co, 16 River Rd, Chatham, NJ.

(H-51) Analysis and Control Instruments—Catalog, 16 pp. Explains operation of instruments used in mass spectrometry, leak detection, chromatograph, moisture monitoring for laboratory or process control. Analytical & Control Div, CEC, 360 Sierra Madre Villa, Pasadena, Cal.

(H-52) Airborne Fuel Systems—Catalog, 12 pp. Describes pumps, valves and regulators used for refueling, transfer and engine supply. Includes equipment for water, avgas, rocket fuel. J C Carter Co, 671 W 17 St, Costa Mesa, Cal.

(H-53) Engines—Bulletin, 6 pp. Contains tables of hp and torque at speed and other data for diesel, natural gas, butane, propane and gasoline engine and power units. Waukesha Motor Co, W St Paul Ave, Waukesha, Wisc.

(H-54) Thermostats—Bulletin, 4 pp. Describes precalibrated, sealed, bimetallic type with temperature range to 300F. The Franklin Dales Co, 180-184 E Mill St, Akron 8, Ohio.

(H-55) Limit Switches—Bulletin, 4 pp. Furnishes dimensions, ratings and wiring diagrams for one, two and three pole heavy duty machine tool types. R B Denison Mfg Co, 386 Broadway, Bedford, Ohio.

(H-56) Solenoids—Catalog, 28 pp. Describes shock mounted industrial types. Range is from miniature to models with 50 lbs pull. Detroit Coil Co, 2435 Hilton Rd, Ferndale 20, Mich.

(H-57) Closed Circuit Tv—Bulletin, 6 pp. Describes basic equipment, accessories for control, security, monitoring. Diamond Electronics Div, Diamond Power Specialty Corp, Box 415, Lancaster, Ohio.

(H-58) Industrial Television—Bulletin, 6 pp. Describes closed circuit system specially designed for heavy duty use under nonideal conditions. Diamond Electronics Div, Diamond Power Specialty Corp, Box 415, Lancaster, Ohio.

(H-59) Circuit Breakers—Data sheets, 7 pp. Provides ratings, characteristics curves for miniature overcurrent and thermal magnetic breakers. E-T-A Products Co of America, 6284 N Cicero Ave, Chicago 46.

(H-60) Motor Starting Thermal Relay—Brochure, 4 pp. Switch is designed to protect windings of motor from overheating and disconnect start windings. Circuits, operating curves given. E-T-A Products Co of America, 6284 N Cicero Ave, Chicago 46.

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select the motor needed for your application

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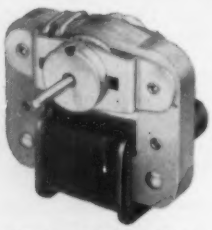
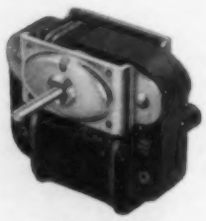
A-C SHADED POLE UNIDIRECTIONAL MOTORS FOR COMMERCIAL APPLICATIONS



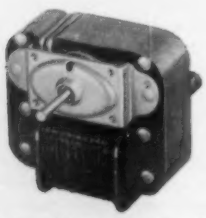
AYAA — DYAA — KYAA

Specifications:
Rated horsepower .0007 to .0010
Length .....1-1/8" plus shaft
Dimensions.....2-7/32" x 2-1/4"
Remarks ....Exceptionally small and compact
Typical applications — fan blades, blowers, roll chart drives, phonographs, and gear trains.



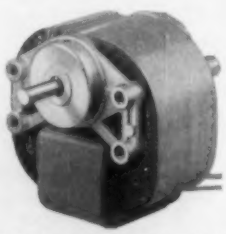
DYAB — KYAB

Specifications:
Rated horsepower .0017 to .0066
Length ....1-5/8" to 2" plus shaft
Dimensions....2-3/8" x 2-19/32"
Remarks ....High starting torque
Typical applications — slide projector fans, hair dryers and refrigerators, vending machines, office machines, and rotisseries.



DYAF — KYAF — OYAF — CYAF

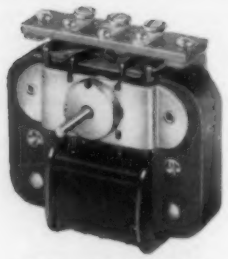
Specifications:
Rated horsepower .0045 to .032
Length .....1-5/8" to 2-9/16" plus shaft
Dimensions....2-21/32" x 2-3/4"
Remarks ....High running torque
Typical applications — fans for heaters, deodorizers and electronic equipment; blowers and gear trains.



AYAR — BYAR — CYAR — DYAR EYAR

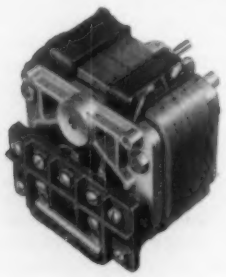
Specifications:
Rated horsepower .005 to .050
Length .....1-29/32" to 3-11/32" plus shaft
Dimensions.....3-1/8" x 3-1/4"
Remarks .....High start or high power rotors available
Typical applications — pumps, humidifiers, vaporizers, combustion and industrial controls.

A-C SHADED POLE REVERSIBLE MOTORS



AYAG — AYAE — BYAE

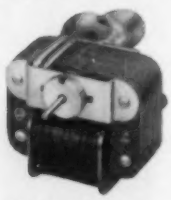
Specifications:
Rated horsepower .00015 to .006
Length .....1-13/64" to 1-53/64" plus shaft
Dimensions .....3" x 2-7/8"
Remarks . Adaptable to 1 or 2-phase operation and electronic control
Typical applications — servomechanisms, remote switching and positioning devices, and pen drives.



CYAE

Specifications:
Rated horsepower .0055 to .04
Length .....3-1/8" plus shaft
Dimensions .....3-7/8" x 3-7/8"
Remarks . Adaptable to 1 or 2-phase operation and electronic control
Typical applications—servomechanisms, recording instruments and automatic weighing machines.

A-C SHADED POLE SYNCHRONOUS MOTORS



DYAJ — KYAJ

Specifications:
Rated horsepower .0043 to .0086
Length . .1-3/4" to 2-1/8" plus shaft
Dimensions ...2-11/32" x 2-19/32" or 2-23/64" x 2-19/32"
Remarks ...Develop 30 times power of ordinary clock motors
Typical applications—oscillographs, scoreboard timers, viscometers, facsimile recorders, x ray timers, and microfilm cameras.

A-C GEARED MOTORS

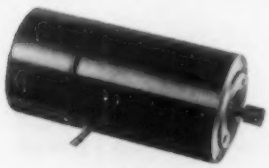
SYNCHRONOUS UNIDIRECTIONAL
REVERSIBLE

DOUBLE-PLATE

ENCLOSED TYPE

Barber-Colman a-c geared motors provide ratios from 4:1 to 1,333,800:1. Heavy duty gears and output shaft plus long life lubrication add to the reliability of these geared motors.

A-C 400-CYCLE MOTORS



AYLO

Specifications:
Type . . Split-phase capacitor, squirrel cage rotor
Rated horsepower . . . up to 40 mhp intermittent duty
Voltage . . . . . 115 V a-c
Rated speed . . . . 9500 to 11,000 rpm
Length . . . 2.20″ excluding shaft and brake
Diameter . . . . . 1.50″
Brake . . . . 400-cycle brake optional

A-C & D-C TACHOMETER GENERATORS

For Commercial Installations

AYAE

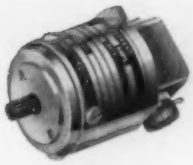
Type AYAE a-c reversible shaded pole motor acts as a low-cost, rugged, accurate, and dependable a-c tachometer or rate generator.

Precision For Military Usage

BYLM

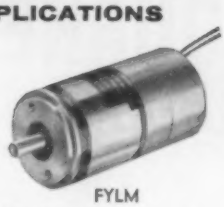
BYLM and FYLM generators are capable of output voltages up to 40 volts per 1000 rpm, with high linearity and low ripple content. Excellent for servo rate feed back.

6-115V D-C PRECISION PERMANENT MAGNET, REVERSIBLE MOTORS FOR AIRBORNE AND INDUSTRIAL APPLICATIONS



BYLM

Specifications:
Rated horsepower . . . . . up to 0.1 intermittent duty
Rated speed . . 5,000 to 20,000 rpm
Power input . . . . . 7 to 155 watts
Length . . . . . 2.19″ to 3.19″ excluding shaft
Diameter . . . . . 1.50″

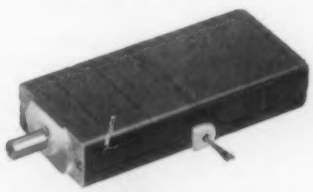


FYLM

Specifications:
Rated horsepower . . . . . up to .055 intermittent duty
Rated speed . . 5,000 to 20,000 rpm
Power input . . . . . 2 to 70 watts
Length . . . . . 1.77″ to 2.40″ excluding shaft
Diameter . . . . . 1.25″
Features . constant brush pressure; R3 bearings; 3/16″ dia. shaft.

DYLM — EYLM

Specifications (EYLM only):
Rated horsepower . . . . . up to .055 intermittent duty
Rated speed . . 5,000 to 20,000 rpm
Power input . . . . . 7 to 155 watts
Length . . . . . 1.83″ to 2.45″ excluding shaft
Diameter . . . . . 1.38″
DYLM is a split series motor in the same envelope.



GYLM with Matching gearhead

Specifications:
Rated horsepower . . . . . up to .040 intermittent duty
Rated speed . . 2,000 to 24,000 rpm
Power input . . . . . 3 to 60 watts
Length . . . . . 1.97″ excluding shaft and gearhead
Diameter . . . . . .75″ x 1.63″
Remarks . . . Rectangular gearhead optional, as illustrated.

BLOWERS, GEARHEADS, RIGHT-ANGLE DRIVES, FILTERS, GOVERNORS, MAGNETIC BRAKES

Gearheads

Right-Angle Drives, Filters

Barber-Colman d-c motors can be adapted to a variety of uses. Several sizes and styles of blowers and gearheads are available. Right-angle drives and multiple-shaft outputs can also be had for special applications. Radio noise filters, governors, or magnetic brakes furnished if desired.

D-C BATTERY-OPERATED ECONOMY MOTORS

AYQM

BYQM

Specifications:
Rated Horsepower . . up to 1 mhp
Voltage . . . . . 4.5 to 30 V d-c
Rated speed . . . . 1200 to 6000 rpm (governed)
Power input . . . . . 1 to 5 watts
Length . . . 1.54″ to 1.69″ excluding shaft
Remarks . . Patented integral governor for battery operation. Reversible.

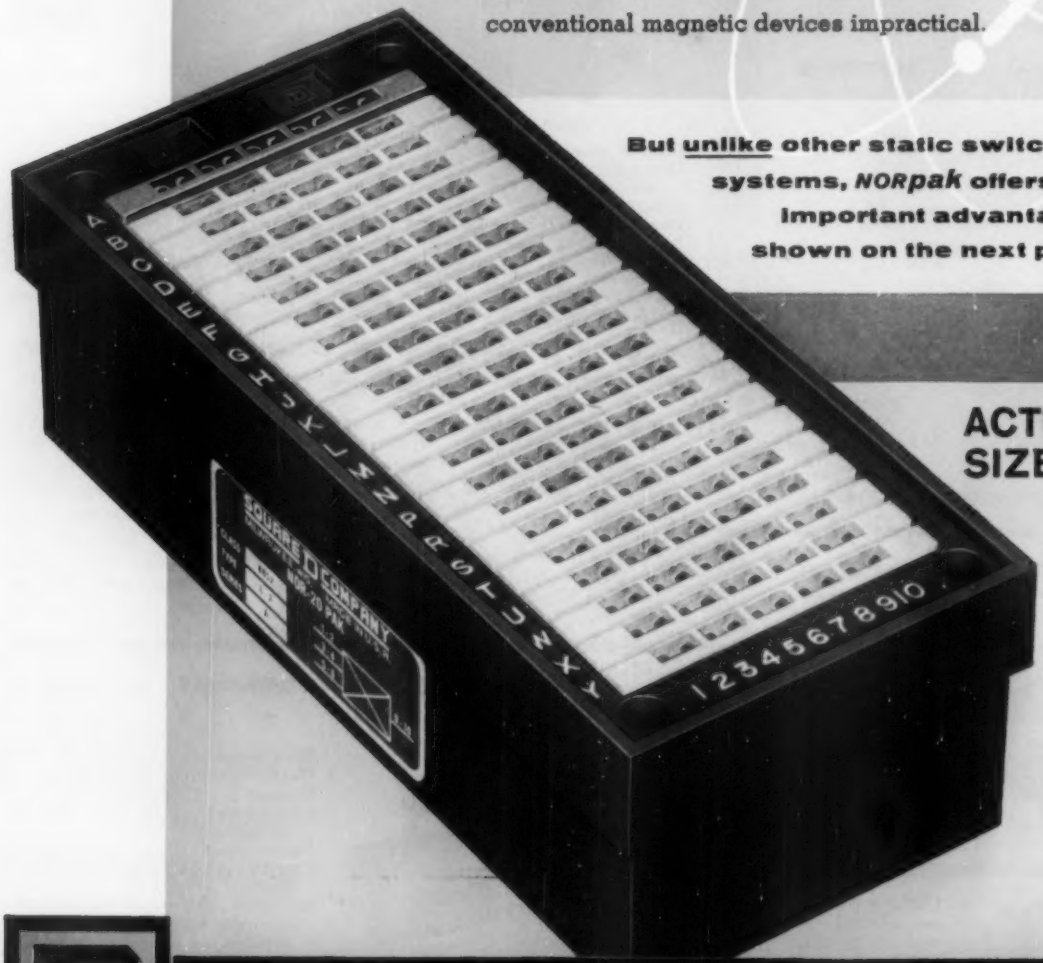
BARBER-COLMAN COMPANY

Dept. I, 1212 Rock Street, Rockford, Illinois

SQUARE D announces NORpak

NORpak is a significant advance in the field of static switching. Like other static systems, ***NORpak*** performs the functions of machine tool relays, stepping relays, latching relays and timers—all without contacts or motion of any kind. Like other static systems, ***NORpak*** is ideal for applications where speed is important—where reliability and long life are essential—where conditions make conventional magnetic devices impractical.

But unlike other static switching systems, *NORpak* offers the important advantages shown on the next page . . .



ACTUAL SIZE

SQUARE D COMPANY

—A SIMPLER, FASTER, STATIC CONTROL!

EASIEST TO APPLY

The transistor NOR unit is the basis of **NORpak.** All logic functions—AND, OR, NOT, MEMORY—can be accomplished with combinations of this single NOR unit. **NORpak** is *not* complicated—it's easy to apply to conventional circuits. Units are color-coded for quick identification. Simple DC circuit eliminates worry about phase relationships.

UNMATCHED SPEED

NORpak provides switching at rates up to 25,000 per second—faster than any other industrial static system.

SMALLEST COMMERCIAL PACKAGES

NORpak is available in the form of individual components, or in completely engineered systems. Components are offered in 6 and 20 paks, require only 1/4th the equivalent relay panel space, and weigh less than components of other static systems.

EXTRA DEPENDABILITY

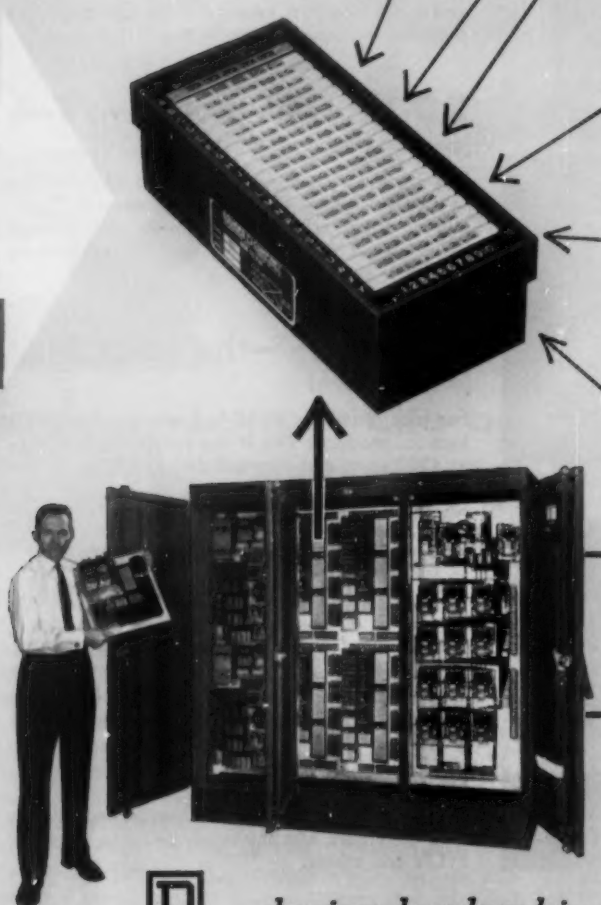
NOR units have been time-tested in computer use for years. They are not subject to wear, will give top performance indefinitely, and provide unfailing circuit fidelity.

SIMPLE TO USE

Optional monitor lights give visual evidence of proper performance. Simple dynamic sequence tester checks individual NOR units in operation.

EXPERT APPLICATION HELP

Field specialists, factory-trained in all aspects of **NORpak,** can give you on-the-spot answers to any application questions.



NORpak is available as individual components for application to specific control functions, or as completely engineered systems ranging from the smallest to the largest panels

• *Write for the complete story on* **NORpak** *—its theory, application and operation. Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin*

D ...design leadership

wherever electricity is distributed and controlled

CIRCLE 407 ON READER SERVICE CARD 407

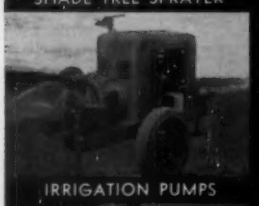
MOTOR, ENGINES AND CONTROLS

INDUSTRIAL ENGINES... with Jeep® DEPENDABILITY!

These three hard-working engines were designed **especially** for industrial use. They have the traditional 'Jeep' toughness and reliability — plus "Keypoint Engineering" that gives the Jeep its extra stamina. The parts that do the most work are built the strongest. Just one example of the sound engineering sense that goes into Jeep engines, keeping them in their best fighting trim. The result — no weak spots to cause expensive breakdowns. All three engines have positive valve rotators and stellite or eatonite valves and valve seat inserts to insure a long life of trouble-free operation.

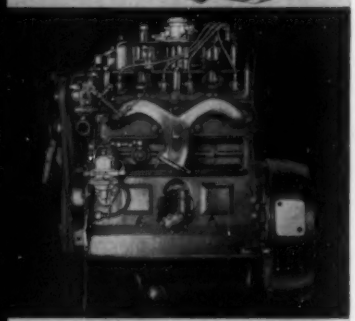
RAIL SWITCHING UNIT

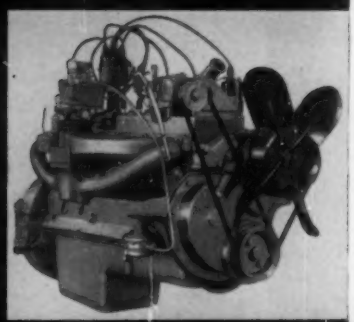
SHADE TREE SPRAYER


IRRIGATION PUMPS

HI LIFT TRUCK

LEAF COLLECTOR — and countless other uses....





20-45 HP—the Jeep L-4

(continuous duty)

This 4-cylinder engine combines the smoothness of a six with the economy of a four. It's an improved and industrialized version of the engine that powered the famous Jeep in two major wars.

20-55 HP—the Jeep F-4

(continuous duty)

This is the only F-head 4-cylinder design built today — the most efficient and economical "four" available to industry. F-head design permits large intake valves for breathing qualities superior to L-head or OHV engines.

33-65 HP—the Jeep 'Six'

(continuous duty)

For jobs requiring 33-65 horsepower, this 'six' is tops... produces 143 ft/lbs for continuous duty at 1200 rpm, and can still deliver 132 ft/lbs for continuous duty at 2600 rpm!

THE POWER UNIT

Available with all Jeep Industrial engines, this is a complete unit from radiator to SAE bell housing. The heavy gauge housing affords complete accessibility to the enclosed engine through a hinged, divided top and removable side panels. Each Jeep power unit is operatable at the moment of delivery.

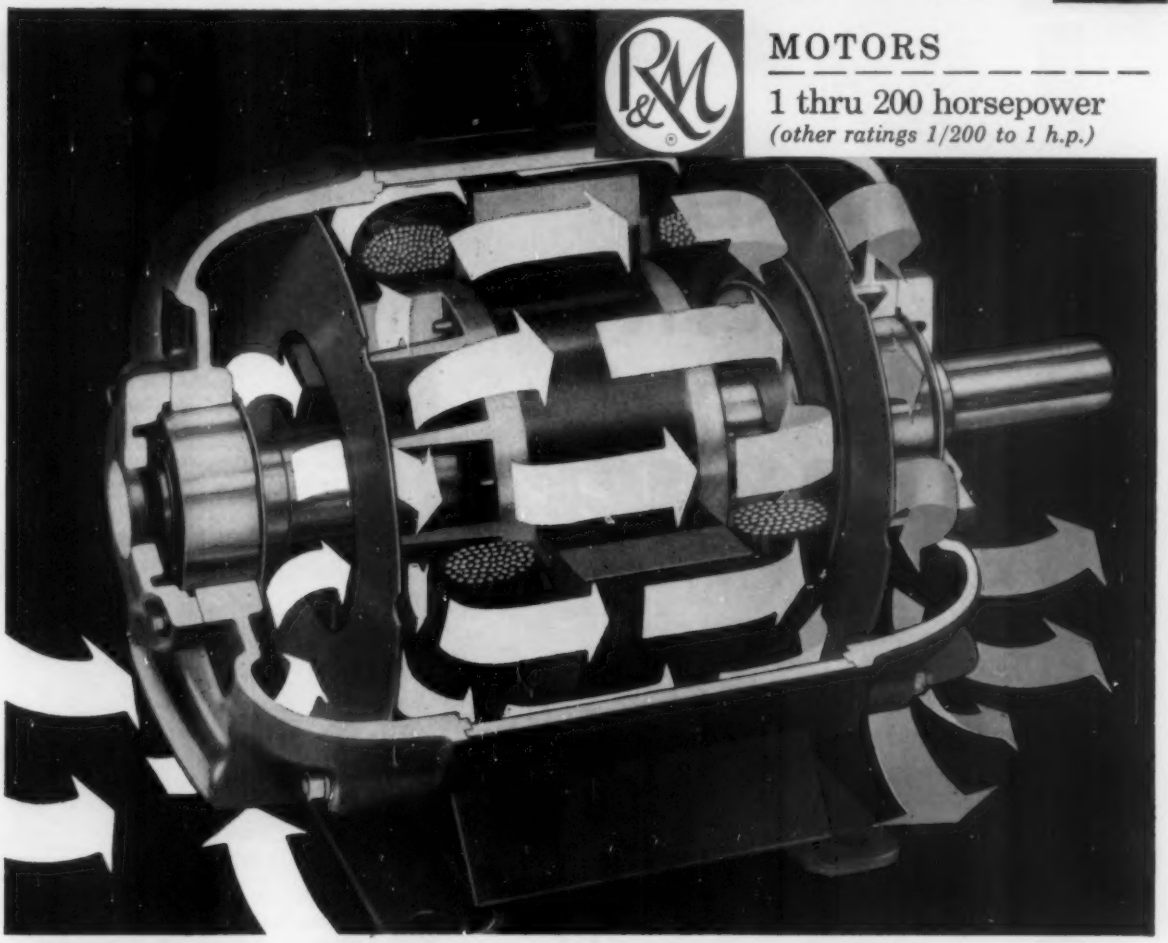
Accessories

Many available, including mechanical and velocity type governors, Murphy safety switches, Rockford PTO's and others.

Send for Complete Details on Prices, Design Details, and Power Curves

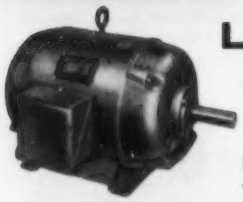
KAISER WILLYS MOTORS

WILLYS MOTORS, INC., Industrial Engine Dept., Toledo, Ohio



MOTORS

1 thru 200 horsepower
(other ratings 1/200 to 1 h.p.)

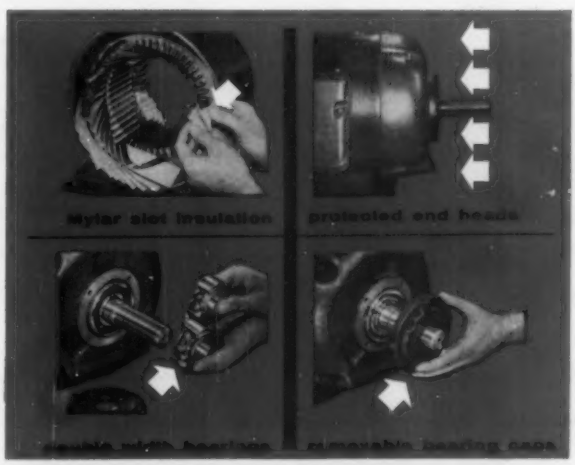


Longer Life because High Velocity *"Dual-Sweep"* ventilation *Cools and Cleans!*

ROBBINS & MYERS "Dual-Sweep" ventilation is a new concept in high velocity internal cooling and cleaning, designed to greatly prolong motor life. Tandem fans—one pushing, one pulling—create end-to-end ventilation that eliminates "dead" areas and converging air currents which deposit dirt. Venturi baffles at each end of the motor direct air in a washing action over and around end coils where it's most needed. Passages between field and outer shell form a "cylinder of air" which carries off motor heat.

R&M motors' long-life insurance also includes these features: Mylar* insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . double width bearings with extra-large grease capacity . . . end heads that offer full height protection . . . removable caps for quick bearing inspection and re-lubrication. For details, write today for Bulletin 520-PRE.

**DuPont registered trademark*



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

CIRCLE 409 ON READER SERVICE CARD 409

INCREASE PRODUCTIVITY WITH Wagner® QUALITY MOTORS

Boost the productivity of the equipment you design by providing motor drives that will operate dependably, with a minimum of down time for maintenance. Choose a motor that is matched to the job, with the proper speed . . . horsepower . . . voltage—that has the right enclosure for your application . . . drip-proof . . . totally-enclosed . . . explosion-proof.

Chances are, you can find the exact motor you need in the complete line of Wagner standard motors . . . a well-known, completely dependable motor with a reputation for quality. A few of the many motors in the Wagner line are shown here. Their excellent performance in their specific applications, their price and prompt delivery make them a sound choice for your equipment.

OTHER WAGNER MOTORS
In addition to the motors shown here, Wagner also furnishes Increment type motor and starter combinations, Multispeed motors, Wound rotor motors, Jet pump motors, Vertical and flange mounted motors, and Air-over motors. Consult your nearby Wagner Sales Engineer, or write for information.

¼ hp Type RK

Capacitor-start. General purpose single-phase motors that operate in any position—provide quick, trouble-free starting—pack plenty of power into little space. ⅛ through ¾ hp. Also in integral ratings through 5 hp.

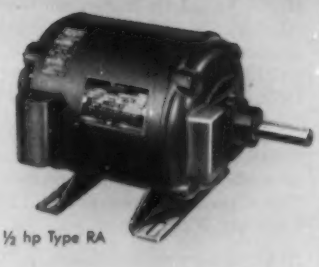
50 hp. Type DP

Doubly Protected (Type DP). Cast iron frames and endplates protect against corrosion. Drip-proof enclosures are designed for protection against falling or splashing liquids. Sleeve or ball bearing, 1 through 125 hp.

400 hp Type ZP

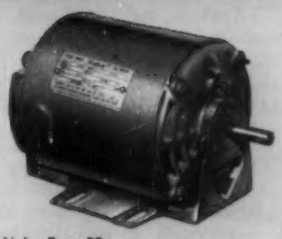
Tube Ventilated. Cooler running motors for heavy duty applications—big fans, blowers, pump drives. Tube cooling system holds operating temperatures within specified limits. Standard TEFC or explosion-proof through 500 hp.

FRACTIONAL HP MOTORS



½ hp Type RA

Repulsion-start Induction. Single-phase motors that make tough starts easy. Start heavy loads with extremely low starting current—stand up under long service. ⅛ through ¾ hp. Also in integral ratings through 15 hp.



¼ hp Type RB

Split-phase. Small, light weight single-phase motors designed for low starting torque requirements. These motors can solve many application problems economically. 48 frame, ⅛, ¼, ½ hp.

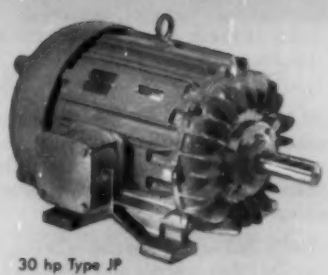
½ hp Type RP

Polyphase Squirrel-cage. General purpose, normal torque polyphase motors in fractional horsepower ratings. 56 frame motors for machine tools, pump, fans, compressors where polyphase power is used.

INTEGRAL HP MOTORS

900 hp Type RP

Open Type Polyphase Squirrel-cage. Drip-proof. Suitable for all general purpose applications. In 583 frame and larger steel frames. Sleeve or ball bearings. Ratings through 1000 hp.



30 hp Type JP

Extra Protected (Type EP). TEFC motors give complete protection against dust, abrasives, fumes or chips. Cast iron frames protect against corrosion. Also in Explosion-proof (Type JP). Ribbed frames, 1 to 100 hp, smooth frames, 125 to 250 hp.

10 hp Type RP

Extra Quiet Polyphase. Smooth running, resilient mounted motors, with sleeve or ball bearings, in ratings through 10 hp. Can be mounted on walls or ceilings, as well as in normal horizontal position.

7½ hp Integral Type

Gearmotors. These compact gearmotors have greater than usual capacity, cast iron frames and housings for corrosion resistance, are available with open-protected or TEFC motors. Integral-type or all-motor type.

25 hp Type DP

Close-coupled Pump Motors. These normal torque polyphase motors, in ratings 1 through 100 hp, are available in face mounted models with special shaft extensions, for direct connection to centrifugal pumps.

7½ hp Polyphase

Hermetic Motors. For sealed refrigeration and air conditioning units, Wagner builds hermetic motors in both single-phase and polyphase squirrel-cage types, in fractional and integral ratings to 600 hp.

WM59-15

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Wagner Electric Corporation

6406 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

SERVING 2 GREAT GROWTH INDUSTRIES . . . ELECTRICAL - AUTOMOTIVE

CIRCLE 411 ON READER SERVICE CARD 411

catalogs and bulletins.....continued

(H-61) Electrical Control and Distribution—Bulletin, 8 pp. Describes in general terms switchboards, control panels, load banks, high voltage switchgear and others. Mullenback Div, Electric Machinery Mfg Co, 2100 E 27 St, Los Angeles 58.

(H-62) Cam Timers—Catalog, 16 pp. Describes recycling sequence timers, drum controllers and accessories. Electric Switch Corp, Box 41037, Indianapolis, Ind.

(H-63) Variable Speed Drives—Brochure, 8 pp. Dc motors from 1/50 to 3 hp plus full or half wave rectifier-controllers give variable or constantly regulated speed. Electro-Devices, Inc, 4-6 Godwin Ave, Paterson, NJ.

(H-64) Variable Speed Drives—Brochure, 8 pp. Describes electronic motor speed control systems. Includes dimensions, ratings, applications. Electro Devices, Inc, 4-6 Godwin Ave, Paterson 1, NJ.

(H-65) Electric Tachometers—Bulletin, 4 pp. Shows operating ranges and dimensions for indicators and generators. The Electro-Mechano Co, 241 E Erie St, Milwaukee, Wisc.

(H-66) Motors and Actuators—Brochure, 29 pp. Describes electrically powered rotary and linear actuators; ac and dc motors to about 9.5 hp. Applications are in missiles, aircraft, industry. Electronic Specialty Co, Eemco Div, 4612 W Jefferson, Los Angeles 16.

(H-67) Proximity Sensors—Data sheets, 29 pp. Describes magnetic pickups, tachometers, accessories and complete counting and control systems. Gives pickup specifications and characteristics curves. Electro Products Laboratories, Inc, 4501 N Ravenswood Ave, Chicago 40.

(H-68) Rotary Switches—Bulletin, 4 pp. Shows single and multipole or ganged switches rated from 3 to 200 amps. Electro Switch Corp, 167 King Ave, Weymouth, Mass.

H-69) Filters—Brochure, 8 pp. Illustrates construction details of oil filters and filter cases. Engine Life Products Corp, 115 S Granada Ave, El Monte, Cal.

(H-70) Electric Controls Components—Bulletin, 8 pp. Describes pushbutton stations, speed sensitive switches, relays, other components and complete control panels. The Euclid Electric & Mfg Co, 50 Edwards St, Madison, Ohio.

(H-71) Motors and Blowers—Catalog, 18 pp. Presents dimensions, performance data and curves for two, four and six-pole induction motors from 1/500 to 1/5 hp; centrifugal blowers rated from 15 to 320 cfm. Fasco Industries, Inc, Augusta St, Rochester, NY.

(H-72) Controls and Instrument Components—Brochure, 4 pp. Presents differentials, cams, synchros, servo motors and couplings. Ford Instrument Co, Div of Sperry Rand Corp, 31010 Thomson Ave, Long Is City 1, NY.

(H-73) Controls—Catalog, 35 pp. Describes components and complete controls such as starters, ac and dc pump alternators, switchboards, ac ground contact indicators, others. Some are explosion proof. Gemco Electric Co, 25685 W Eight Mile Rd, Detroit 40.

(H-74) Explosion-proof Controls—Bulletin, 4 pp. Describes aluminum enclosures, pushbutton stations, modular enclosures. Gemco Electric Co, 25685 W Eight Mile Rd, Detroit 40.

(H-75) Rotating Cam Limit Switches—Bulletin, 8 pp. Provides dimensions, specifications, set-up instructions for variety of switch using one adjustable type cam for most jobs. Gemco Electric Co, 25685 W Eight Mile Rd, Detroit 40.

(H-76) Flow, Level and Position Indicators—Brochure, 16 pp. Explains operation and uses of indicating devices with electrical outputs. The Gems Co, Inc, Sheppard Lane, Farmington, Conn.

(H-77) Industrial Controls—Catalog, 88 pp. Describes controls and accessories for refrigeration, air conditioning, oil burners, automation, aircraft, electronics, appliances, heating. Also power driven valves. General Controls Co, 801 Allen Ave, Glendale 1, Cal.

(H-78) Loop Tape Recorder—Brochure, 14 pp. Explains operation of tape recorder which records pulses at stepped intervals along endless tape loop in removable cartridge. Stromberg-Carlson Div of General Dynamics Corp, 100 Carlson Rd, Rochester, NY.

(H-79) Relays—Brochure, 24 pp. Lists specifications of telephone type relays in multicontact, plug-in, high voltage and other models. Stromberg-Carlson Div of General Dynamics Corp, 100 Carlson Rd, Rochester, NY.

(H-80) Dc Motors—Bulletin, 12 pp. Describes industrial types ranging from one to 150 hp. Includes dimensions and construction features. General Electric Co, Dc Motors & Generators Dept, 3001 E Lake Rd, Erie 1, Pa.

(H-81) Large Dc Motors—Bulletin, 8 pp. Describes general purpose motors for steel, paper, similar applications. Ratings are: Constant speed, 125 hp and larger; adjustable speed, 25 to 200 hp. General Electric Co, Dc Motor & Generator Dept, 3001 E Lake Rd, Erie 1, Pa.

(H-82) Special Dc Motors and Generators—Bulletin, 8 pp. Shows capabilities for producing to unusual requirements. General Electric Co, Dc Motor & Generator Dept, 3001 E Lake Rd, Erie 1, Pa.

(H-83) Fhp Motors—Catalog, 11 pp. Describes ac, dc motors for applications such as vending machines, phonographs, fans. The General Industries Co, Taylor & Olive Sts, Elyria, Ohio.

(H-84) Servo Motors—Brochure, 4 pp. Contains performance curves, specifications, dimensions of 10, 20 and 30 watt motors. Genisco, Inc, 2233 Federal Ave, Los Angeles 64.

(H-85) Synchronous Motors—Brochure, 4 pp. Gives performance curves, dimensions and construction of motors from 1/100 to 1.0 hp. Ginisco, Inc, 2233 Federal Ave, Los Angeles 64.

(H-86) Magnetic Reed Switches—Brochure, 4 pp. Ratings and possible uses shown for sealed, gas-filled magnetically actuated switches with mercury pool, mercury wetted or dry contacts. Hamlin Inc, Lake & Grove Sts, Lake Mills, Wisc.

(H-87) Sub-fhp Motors—Catalog, 16 pp. Gives ratings, dimensions of blowers, blower-heaters, motors as small as 1/750 hp. Heinze Electric Co, 685 Lawrence St, Lowell, Mass.

(H-88) Special Ac Motors—Data folder, 40 pp. Provides dimensions and operating curves for 400 cps small motors. Redesigns available for special service and from 2 to 1600 cps. Hertner Electric Co, 12690 Elmwood Ave, Cleveland.

(H-89) Control Motor—Bulletin, 4 pp. Provides dimensional, electrical, mechanical data on servo type, reversible induction motor for instrumentation, controls. Holtzer-Cabot Motor Div, National Pneumatic Co, Inc, 125 Amory St, Boston.

(H-90) Small Motors—Bulletin, 4 pp. Gives dimensions, construction, characteristics of synchronous, hysteresis-synchronous, induction motors suitable for instruments, office equipment. Holtzer-Cabot Motor Div, National Pneumatic Co, Inc, 125 Amory St, Boston.

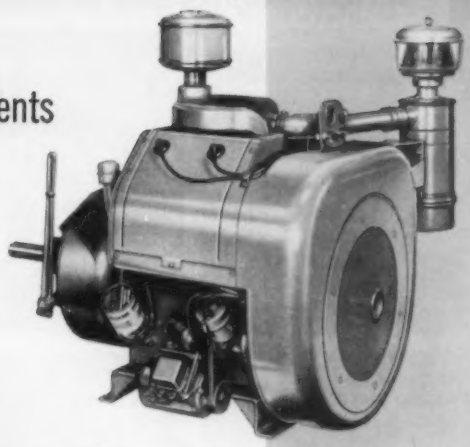
(H-91) Small Capacitor Motors—Bulletin, 4 pp. Describes induction, synchronous and gear types with 10 watt power input. Speed outputs ½ to 1800 rpm. Holtzer-Cabot Motor Div, National Pneumatic Co, Inc, 125 Amory St, Boston.

(H-92) Synchronous Motors—Catalog, 4 pp. Presents dimensions and specifications of heavy duty timing motors. Hurst Mfg Corp, Princeton, Ind.

continued

CIRCLE 413 ON READER SERVICE CARD→

If Heavy-Duty Engine Power Components are on your OEM Design and Specification List...it's time to Investigate and Specify...



CUSTOM ENGINEERED

power by WISCONSIN

Here at Wisconsin you will find the answers to many questions concerned with *Engine Power*. Answers that may help you cut over-all design and development costs to management-applauding levels. A wide choice of "custom-engineered" adaptations are available to meet your specific requirements. Typical examples are listed in another column. But over and above this, consider these basic factors:

You start with a broad range of sizes for power selectivity to fit the job and the machine . . . without *under*-powering or *over*-powering. You have more than a dozen models to choose from — 4-cycle single cylinder, 2- and V-type 4-cylinder, in an overlapping horsepower range from 3 to 56 hp. You get basic heavy-duty design and construction in all details . . . the in-built stamina to stand up to the severest operating conditions. Service-proved on hundreds of thousands of machines the world over.

And you get basic high torque engineering to provide the load-lugging power that hangs on in the clinches . . . rides through the shock loads and the heavy going without stalling. Your equipment gets the credit; the user-customer gets the benefits.

You get AIR-COOLING second to none in the engine field . . . assuring satisfactory operation at all temperatures from sub-zero to 140° F. The equipment user is relieved of all seasonal cooling problems and servicing incidental to ownership of a water-cooled engine. This spells low-cost maintenance and minimum down-time on the job.

You get smooth-running, long-life features such as tapered roller bearings at BOTH ends of the drop-forged crankshaft . . . on *all* engine models from the smallest to the largest.

You get 50 years of specialized engine-building experience . . . counsel that helps to establish a perfect partnership between the OEM customer and the engine builder.

And back of it all, your distributors, dealers and the users of your equipment are back-stopped by an organization of approximately 2,000 Authorized Service Stations, carrying factory parts for *all* Wisconsin models.

This is the package that goes along with Wisconsin "Custom Engineering" . . . at your service for better service to you and your entire organization. . . *at the board, in the plant, and in the field.*

For a briefing on the complete Wisconsin Engine line, write for Bulletin S-249 . . . and tell us about your power problem.

Y-210

WISCONSIN MOTOR CORPORATION
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

Here are just a few of many available WISCONSIN Adaptations

POWER TAKE-OFF: specify your choice of centrifugal clutch; over-center clutch; clutch reduction or reduction assembly in a variety of ratios; adaptor to take a spring-loaded clutch or transmission-torque converter designs.

DIRECT DRIVE: a crankshaft extension to meet your special needs. It's available threaded, tapered, splined, special diameters and lengths, various keys, etc., for close-coupled pumps, generators, and many other machines.

SPEED REGULATION: available in a broad range of governor controls; hand-operated, remote wire-and-lever controls; 2-speed agricultural controls (idle and load speeds), and special provisions to mount controls of your own design.

FUEL SYSTEMS: gasoline, natural gas, and LPG (for domestic applications); and alcohol, kerosene, and No. 1 fuel oil (for export).

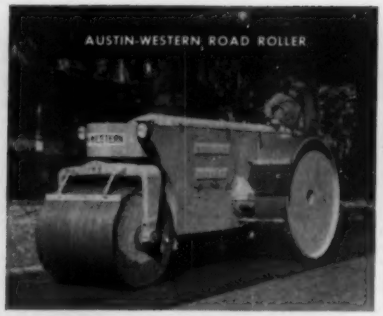
HYDRAULIC POWER: all Wisconsin V4's can be equipped with integrally-mounted hydraulic pumps.

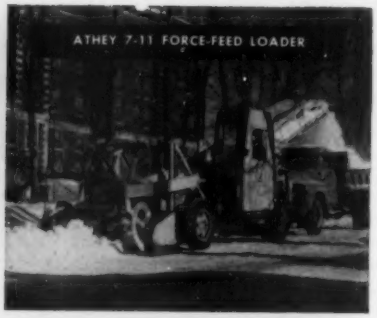
STELLITE EXHAUST VALVES AND INSERTS: regularly supplied with positive type valve rotators, this combination adds from 200% to 500% to valve life. Standard Equipment on 6 Wisconsin Engines but available on all models.

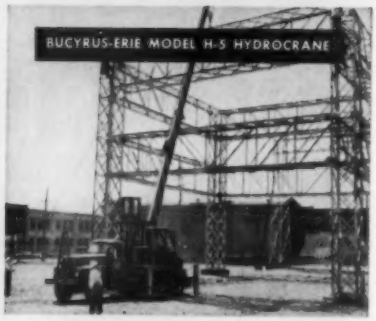
ELECTRICAL EQUIPMENT: electric starter-generator or starter only available for all Wisconsin models, 3 to 56 hp. Solenoid switches and automatic choke, for remote or automatic starting, are also available.

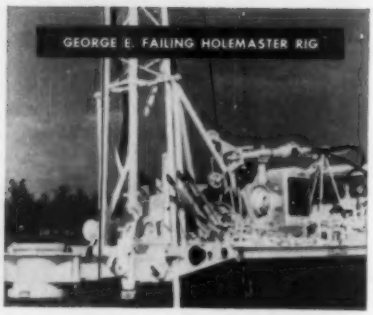
SAFETY DEVICES: low-oil-pressure cut-off switch for 2- and 4-cyl. engines, and high-temperature safety switch for all models.

MISCELLANEOUS ACCESSORIES: automotive and spark-arresting mufflers, pre-cleaners, drive pulleys for flywheel, and rewind starters for ACN and BKN engines.









HERE'S WHY LEADING OEM's POWER WITH DEPENDABLE FORD INDUSTRIAL ENGINES

Spend a few minutes comparing Ford engines to this check list and you'll see why more and more original equipment manufacturers are swinging to Ford power.

Durability and Efficiency! Ford's deep-block construction lessens engine vibration. Short-stroke design reduces friction and wear. Hard-faced, rotating valves provide better seating, mean longer valve life.

Compactness! Ford's compact design with high power-to-weight ratio allows greater freedom of design.

Parts and Service! Ford's world-wide dealer network (over 10,000 Ford Dealerships in U.S. alone) offers prompt, efficient service *wherever you go.*

Wide choice! Ford engines range from 134 to 534 cubic inches—including two highly efficient diesels. All are available as engine assemblies or power units.

Little wonder so many equipment designers, purchasing agents and sales managers are specifying modern Ford power for their equipment. Why not you?

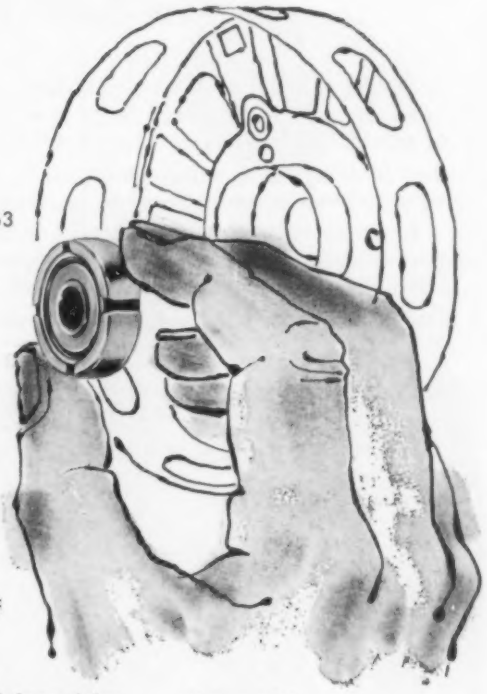
FORD POWER IS RIGHT FOR YOUR EQUIPMENT, TOO!

INDUSTRIAL ENGINE DEPARTMENT, FORD DIVISION, FORD MOTOR CO., P.O. BOX 598, DEARBORN, MICH.

West of Rockies write to:
FORD INDUSTRIAL ENGINE DEPT., P.O. BOX 6787, LOS ANGELES 22, CALIF.
FORD INDUSTRIAL ENGINE DEPT., P.O. BOX 1666, RICHMOND, CALIF.

New Motors by **UNIVERSAL** introduce new free-aligning ball bearing assembly*

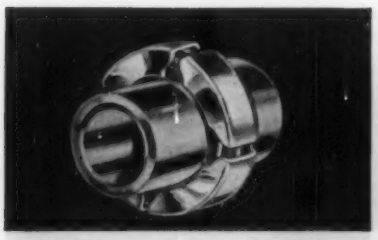
. . . utilizing only the shaft for alignment, the new Universal Ball Bearing Assembly provides:
. . . reduced noise level in ball bearing motors . . .
. . . easier starting regardless of load . . .
. . . elimination of pre-loaded bearings due to misalignment.



Two new UNIVERSAL ELECTRIC motors, Type 523 (4 pole) and Type 563 (6 pole) incorporate an entirely new ball bearing assembly design. The new ball bearing assembly is resiliently suspended in a neoprene collar with the axis of support in the center of the bearing. The bearing is thus inherently in balance and can adjust to any shaft misalignment 100% of the time utilizing only the shaft itself for alignment. This new design requires no pressure to retain the bearing in its position and the bearing cannot be forced from its seat regardless of the amount or type of load placed on the shaft.

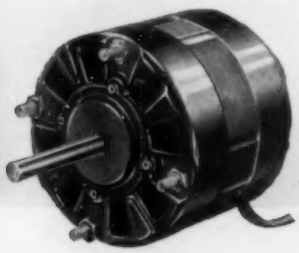
Advantages of the UNIVERSAL ELECTRIC ball bearing design are (1) reduced noise level, (2) permanent cushioned end play, (3) easier starting, (4) elimination of snap rings, shoulders and undercuts thus providing a stronger motor shaft and (5) elimination of preloaded bearings due to misalignment thus resulting in a free running motor with a longer motor life. UNIVERSAL offers the only ball bearing shaded pole motors on the market that can make all of these claims.

*Pat. applied for



Universal Bearings*

Universal Free-Aligning sleeve-type Bearings eliminate fractional HP motor bearing problems due to misalignment. Like the new ball bearing assembly, this revolutionary bearing is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load condition.



UNIVERSAL Electric Motors type 523 and type 563 with the new ball bearing assembly, offer the perfect flat speed torque curve necessary for critical air moving or recorder applications. In addition to these 2 new motors, UNIVERSAL ELECTRIC also is making a new 6 pole sleeve bearing motor Type 63 as well as the standard 4 pole, Type 23. These motors offer maximum performance and efficiency for kitchen ventilators, unit heaters, evaporative coolers, condenser fans, refrigerated cabinets, etc.

Write for complete specifications on your requirements.

55

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 12

CIRCLE 415 ON READER SERVICE CARD 415

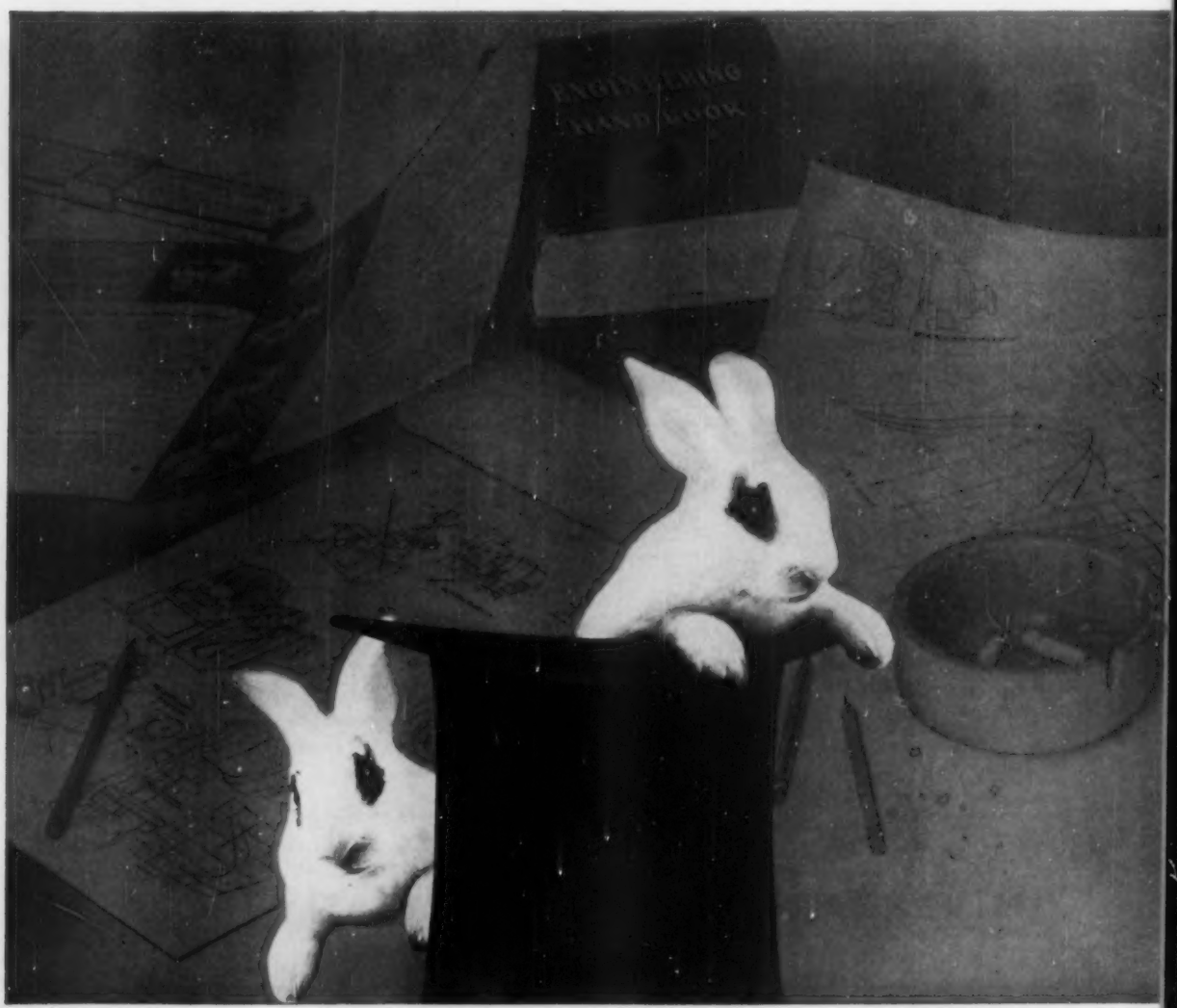
Bring out the FULL MAGIC of your own engineering know-how with Special REULAND Motors

Don't ever let a complicated drive requirement stymie your own ingenuity. If you have a design idea, go right ahead with it... leave the motor adaptation to Reuland.

Reuland cut its eye teeth in the motor business, many years ago, by supplying special motors for new design concepts. And, while our company now supplies many thousands of standard motors each year, we have never lost sight of the industry's continual need for something new.

Reuland's basic "Xpandable" design is ideally suited to special adaptation. For example, there are well over 2000 special designs in the Reuland Special Motor Library... one of which may very likely be close to something you may need right now.

Whether you are doing futuristic doodling... or designing for immediate production... cash in on your own creative designing talents. A single experimental motor, or a production run, will receive the same well known Reuland spirit of cooperation. Why not check into what we say.

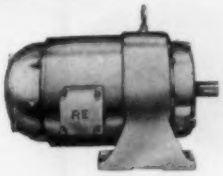


MULTI-DRIVE MOTOREDUCER

Shown here is a typical example of a Reuland multi-drive unit, as adapted for use on a screw conveyor bag filler machine. The primary motor turns the screw for high speed filling. For final, precision filling, a D. C. clutch cuts in the 128 r.pm. Motoreducer. Speed reduction ratios of as much as 100:1 are available.

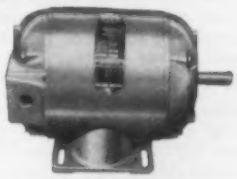
5-STAGE DRIVE CYCLE PACKAGE

A complete, five-stage operating cycle is handled by this one drive package... (1) 100 r.p.m. forward run, (2) immediate stop, (3) fluid-cushioned start again, (4) reverse direction and (5) return at 200 r.p.m. The complete cycle is accomplished by an internal fluid coupling...two-speed, reversing duty motor, gear reducer, and magnetic brake...*within one frame!*



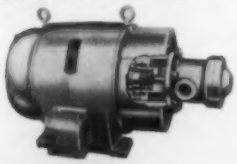
STALL DUTY TORQUE MOTORS

Reuland torque motors can be stalled or "locked" into a load with full current on. The units also automatically adjust their speed to intermittent load changes. Output torques can be changed, as desired, through the use of voltage varying devices. Available in ratings from ½ through 10 foot pounds...for maximum stalls of 5, 10, 20, 60 minute and *continuous*.



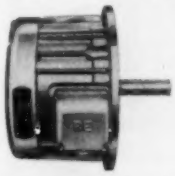
SPLINE COUPLED PUMP MOUNT MOTORS

Reuland spline-coupled hydraulic pump mount motors feature a direct connection between the pump and the motor's shaft... *inside the motor*. The installation is made by simply slipping the spline coupling onto the pump shaft...and attaching the pump to the endbell. The unit eliminates flexible couplings and platform mounts. Reduces mounting space almost 50%. Assures perfect alignment, automatically.



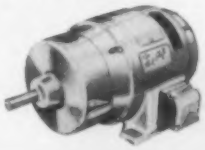
MACHINE TOOL MOTORS

These precision machine tool motors are a completely new type, especially made for the machine tool industry. They are compact in design and built to precise specifications like a fine tool. Their individual dynamic balancing...heavy duty ball bearings...low inertia, lightweight rotor...and even smooth-finished castings, make them a match for the most expensive machine tool.



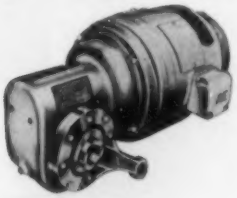
FLUID-SHAFT BRAKEMOTORS

Reuland Fluid-Shaft motors eliminate shocks and jerks and provide a smooth gradual, stepless method of load acceleration. Power is transmitted through an internal fluid coupling and all starting inertias are absorbed in a cushion of oil. The Reuland "doughnut" magnetic brake... mounted on the output side of the coupling ...permits extending the motor shaft right through for load hook-up.



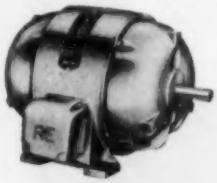
HOLLOWSHAFT WORM MOTOREDUCERS

This unique, right-angle Motoreducer features a *hollow shaft* that permits direct-coupling to equipment by merely inserting the drive shaft of the machine. No other mounting arrangement is required, except the torque arm which serves as an "anchor" for the Motoreducer. Eliminates the need for couplings, brackets, or belt and chain drives. Mounts in very tight areas.



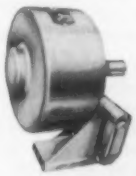
MULTI-SPEED MOTORS

Basic designs consist of three predetermined speed rating selections; 2-speeds, 3-speeds and 4-speeds. The motors are also available with three torque-horsepower-speed combinations. (1) Constant torque ...h.p. varies directly with r.p.m. (2) Variable Torque...h.p. variation is proportionate to the square of the speed, and (3) Constant horsepower...wherever h.p. need is constant regardless of operating speed.



DISC-TYPE MAGNETIC BRAKES

Reuland "through-shaft" magnetic brakes feature a fast and sure direct action principle. Levers and linkage are eliminated by a simple attraction and release action between the armature and "doughnut" type magnet. Available for use with all makes of motors in (1) *endbell* type, (2) *foot mounted* and (3) *foot mounted–complete with own bearings and shaft.*



MODERN POWER FOR MODERN-DAY PRODUCTS

...all in lightweight aluminum frames!

REULAND MOTORS

Our new general catalog will come in handy. Sent free on request. Describes the exclusive Reuland "Xpandable" design idea...Tells how you can benefit by using our free Special Motor Library.

REULAND ELECTRIC COMPANY

WESTERN DIVISION: *Alhambra, California*
EASTERN DIVISION: *Howell, Michigan*
Distributors in all principal cities

REFER TO SWEET'S PRODUCT DESIGN FILE, SECTION 5A

The BODINE line—
a complete line of fractional hp motors

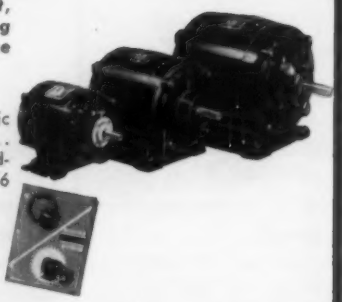
More than 3500 standard built-to-order motors

...for blowers, pumps, coin-handling units, communication equipment, therapeutic devices, sound-recording and reproducing equipment, machine tools, and similar applications

BODINE TYPE N MOTORS

These motors are available in three basic sizes... the smallest 3⅜" in diameter... the largest 5½". Almost any type winding. Standard ratings from 1/150 to 1/6 hp at 1725 rpm.

Write for bulletin "S"



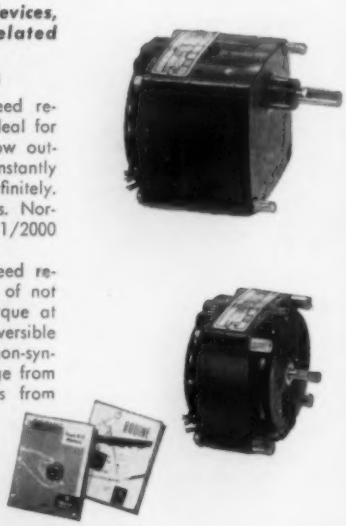
...for instruments, timing devices, control apparatus, and related equipment

BODINE TYPE K-2 MOTORS

Available with and without speed reducers. Model without reducer ideal for equipment requiring relatively low output. Overall height only 2⅜". Instantly reversible. Can be stalled indefinitely. Synchronous or non-synchronous. Normal 60-cycle output ranges from 1/2000 to 1/500 hp on continuous duty.

Models with parallel shaft speed reducer have high starting torque of not less than 150% of full load torque at room temperature. Quickly reversible under load. Synchronous or non-synchronous. Drive shaft speeds range from 300 to 0.7 rpm...torque ratings from 1.3 in. oz. to 120 in. oz.

Write for bulletin 1024A
...for speed reducer models, bulletin 1023B

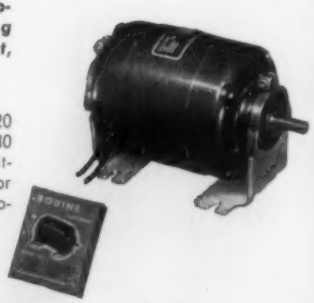


...for use in office machines, automatic phonographs, circulating pumps, air conditioning equipment, and similar applications

BODINE TYPE U MOTORS

"U" type motors are available in 1/20 and 1/15 hp at 1725 rpm...and in 1/30 hp at 1125 rpm. Diameter 4⅜". Split-phase construction. Resilient mounting for quiet operation. Thermal overload protection.

Write for bulletin 1028



295 different stock types and sizes ready for fast shipment!

BODINE ELECTRIC CO., 2510 W. BRADLEY PLACE, CHICAGO 18

BODINE
fractional / horsepower
MOTORS

...the power behind the leading products

BODINE SPEED REDUCER MOTORS

...combines motor and speed reducer in one unit, eliminating all cumbersome and complicated speed reducer transmissions such as belts, gears, and chains

...single or double reduction speed reducers for transmitting low torques over a wide range of speeds. Height, 3⅝".

...double worm-gear reducer to deliver moderate torques at low speeds. Height, 4¾".

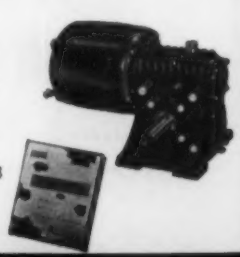
...single reduction, right angle worm gear reducer to deliver moderate torques. Height, 4⅞".

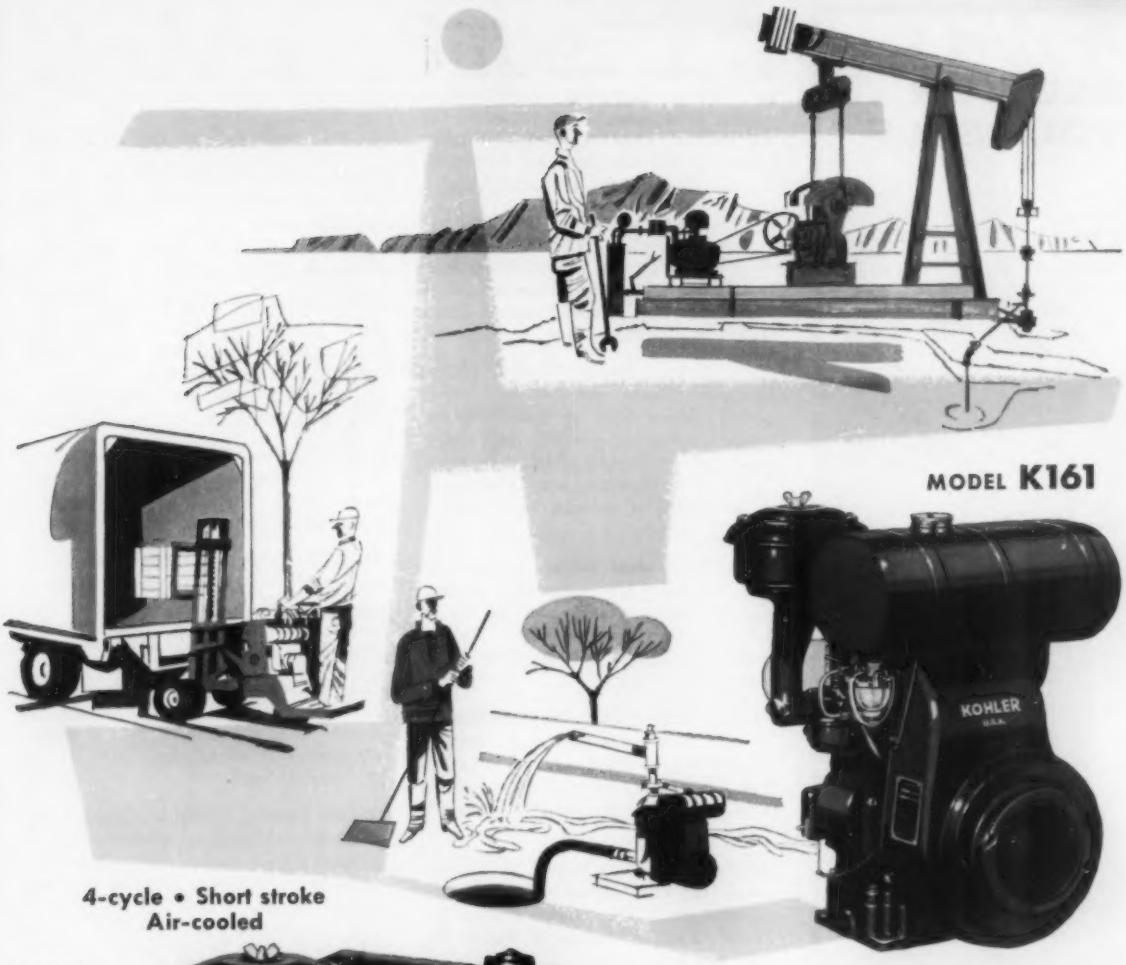
...double worm-gear reducer for transmitting high torques at low speeds. Height, 6⅞".

...single reduction, right angle worm gear reducers for transmitting substantial torques. Height, 6¼".

...heavy duty reducer for continuous driving of heavy loads. Ample reserve for overloads. Height 7⅞". Eight different windings.

Write for bulletin 1022B

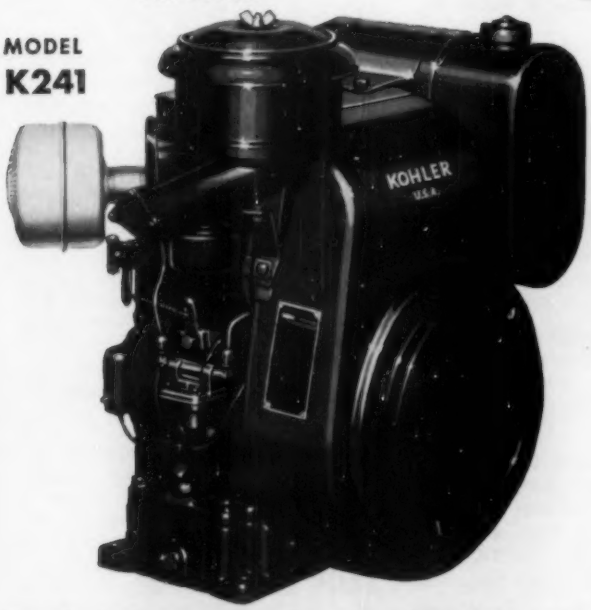




MODEL **K161**

4-cycle • Short stroke
Air-cooled

MODEL
K241



KOHLER ENGINES

Reliable power for quality equipment

Kohler Co. has manufactured internal combustion engines for 40 years.

Kohler engines are rugged, quick-starting, conservatively rated.

Short stroke design gives maximum usable power, cuts engine friction.

Nation-wide sales and service.

Kohler engines power Kohler electric plants, known everywhere for reliability.

FROM 4 TO 24 H.P. *Write for illustrated booklet.*
KOHLER Co. *Established 1873* **KOHLER, WIS.**

KOHLER OF KOHLER

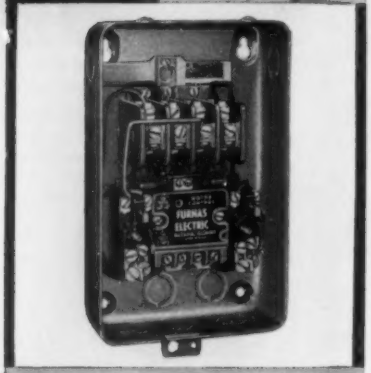
ENAMELED IRON AND VITREOUS CHINA PLUMBING FIXTURES • ALL-BRASS FITTINGS • ELECTRIC PLANTS • AIR-COOLED ENGINES • PRECISION CONTROLS

←CIRCLE 418 ON READER SERVICE CARD

CIRCLE 419 ON READER SERVICE CARD 419

SEE FOR YOURSELF

Sound engineering and field testing are built into the advanced design of all Furnas Electric products, to provide the leading motor controls on the market today.



- Standardized design and exclusive "in-between" starter sizes allow wider application with fewer units.
- Magnet features just one moving part. Dual voltage coils, 110-220 or 220-440 volts at no extra cost.
- Trip-free thermal overload relays. Manual or automatic reset.
- Non-tracking contact block is impact resistant. Visible and front removable silver-cadmium oxide contacts.

SEE FOR YOURSELF! Write today for Bulletin 14-B1 — 1050 McKee Street, Batavia, Illinois.

A86

FURNAS

FURNAS ELECTRIC COMPANY

BATAVIA, ILLINOIS

Sales Representatives in All Principal Cities

catalogs and bulletins.....continued

(H-93) **Ac Motor Starters**—Data folder, 32 pp. Shows operating characteristics, circuits, dimensions, ratings for across the line and reduced voltage starters. Monitor Controller Div of Industrial Electronics Co, Inc, 99 Grove St, Rockland, Mass.

(H-94) **Timing Controls**—Catalog, 50 pp. Provides dimensioned drawings, specifications of synchronous motor driven cam timers, time delay timers, internal timers and running time meters. Industrial Timer Corp, 1407 McCarter Hwy, Newark, NJ.

(H-95) **Control Systems**—Catalog, 16 pp. Describes process, machine tool, other control systems built up from actuators, remote positioners, punched card reader, additional components. Jordan Controls, Inc, 3235 W Hampton Ave, Milwaukee 4 includes table of actuator motor characteristics.

(H-96) **Thermistors**—Brochure, 6 pp. Contains characteristics curves and specifications of thermistors for operation up to 300C. Kidde Aero-Space Div, Walter Kidde & Co, Inc, 669 Main St, Belleville 9, NJ.

(H-97) **Overheat Protection**—Brochure, 8 pp. Describes continuous strip, continuous resetting, thermistor type detector system. Walter Kidde & Co, Inc, Industrial & Marine Div, 669 Main St, Belleville 9, NJ.

(H-98) **Fhp Motors**—Bulletin, 8 pp. Furnishes brief specifications of 42 special application motors. The Lamb Electric Co, Div of American Machine & Metals, Inc, Lake St, Kent, Ohio.

(H-99) **Thermostatic Control Valves**—Brochure, 8 pp. Describes temperature regulators, mixing valves, other components and systems. Lawler Automatic Controls, Inc, 453 N MacQuesten Pkwy, Mount Vernon, NY.

(H-100) **Solenoids and Relays**—Brochure, 8 pp. Gives performance data and dimensions for rotary solenoids, stepping and selective relays, stepping motors. Ledex, Inc, 123 Webster St, Dayton, Ohio.

(H-101) **Fhp Motors**—Brochure, 4 pp. Provides performance, dimensional, construction details for low voltage dc motors. The Leece-Neville Co, 5109 Hamilton Ave, Cleveland.

(H-102) **Gearshift Drives**—Bulletin, 8 pp. Describes combination induction motor and four-speed reducing gear box. Compares unit with other types of variable speed drives. The Lima Electric Motor Co, Inc, Findlay Rd, Lima, Ohio.

(H-103) **Motors**—Bulletin, 8 pp. Provides complete discussion of the motor construction stressing polyester resin winding protection. The Lincoln Electric Co, 22801 St Clair Ave, Cleveland.

(H-104) **Magnetic Plugs**—Catalog, 12 pp. Gives magnet, thread and other data on plugs for removing ferrous chips from oil. Lisle Corp, 807 Main St, Clarinda, Iowa.

(H-105) **Motors**—Brochure, 8 pp. Describes wide variety of motors and built-in couplings, speed reducers. Also magnetic disc brakes. Reuland Electric Co, 3001 Mission Rd, Alhambra, Cal.

(H-106) **Level and Flow Controls**—Bulletin, 24 pp. Explains how each of the controls works in the piping systems diagrammed. Also shows electrical circuits. McDonnell & Miller, Inc, 3500 N Spaulding Ave, Chicago 18.

(H-107) **Machine Tool Motors**—Brochure, 12 pp. Explains factors in making correct motor choice. Marathon Electric Mfg Corp, Wausau, Wisc.

(H-108) **Industrial Engines**—Catalog, 20 pp. Includes straight six and V-8 gasoline engines up to about 150 continuous hp. Marine & Industrial Engine Div, Chrysler Corp, Box 1836, Detroit 31.

(H-109) **Circuit Breakers**—Catalog, 38 pp. Uses range from home to industry to aircraft. Sizes are from ½ to 100 amps. Mechanical Products, Inc, 1824 River St, Jackson, Mich.

(H-110) **Pressure Switches**—Catalog, 90 pp. Describes differential, absolute and gage pressure sensing switches for any media. Meletron Corp, 950 N Highland Ave, Los Angeles 38.

(H-111) **Mercury Switch Controls** – Brochure, 4 pp. Describes switches with sensing elements for detecting temperature, pressure, liquid level. Enclosures vary to fit application. The Mercoid Corp, 4201 Belmont Ave, Chicago 41.

(H-112) **Electric Timer**—Brochure, 4 pp. Provides data on cross-section of timing switches for industrial use and appliances. Miller-Harris Instrument Co, 1134 S First St, Milwaukee.

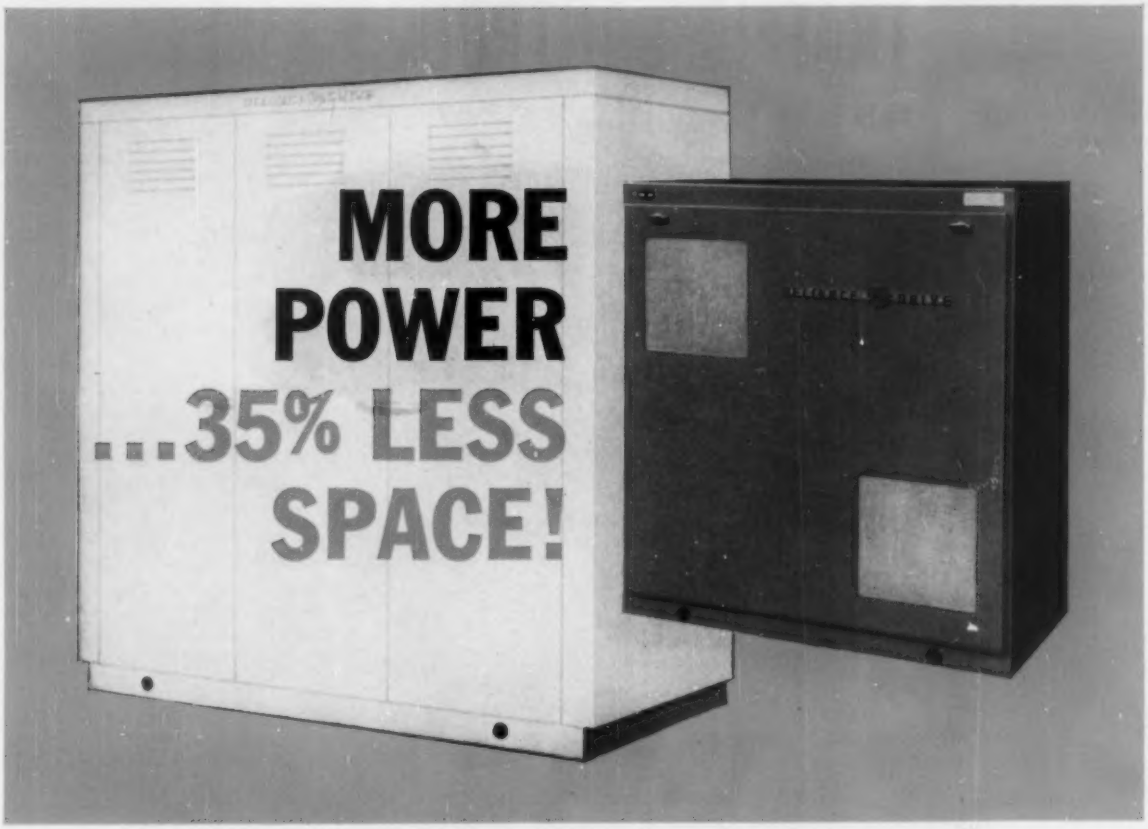
(H-113) **Damper Control Blower**—Brochure, 10 pp. Describes combination blower, damper and controls to provide two-speed, heat or cool operation. Morrison Products, Inc, 16816 Waterloo Rd, Cleveland 10.

(H-114) **Thermostats**—Brochure, 11 pp. Provides dimensioned drawings, specifications for bimetal thermostats in zero to 650F range. Norwalk Thermostat Co, 100 North West St, Norwalk, Ohio.

(H-115) **Fhp Torque Motors**—Bulletin, 4 pp. Presents dimensions, ratings, service conditions of both ac and dc types. Ohio Electric Mfg Co, 5400 Dunham Rd, Maple Hts, Ohio.

continued

Reliance Super 'T' V★S Drives



Both of these control units are rated at 50 horsepower! Actually, the new, small Super 'T' V★S cabinet packs more punch!

LIKE the Reliance Super 'T' Drive Motor, new V★S power units utilize Class B insulation, permitting a more compact unit. 100% overloads of one minute duration are accomplished without failure! Advanced design of ventilation keeps control and power units cooler . . . another reason why smaller size is possible. And service life is substantially extended.

Matched system design of drive motor, power unit and controls produces a highly efficient, integrated drive—to give you a wide range of stepless, variable operating speeds from a-c. circuits.

Super 'T' V★S Drives are available for immediate delivery. Check your Reliance salesman for delivery schedules on the full line, 1—350 hp., Bulletin Number D-2506, has been prepared to give you complete information. Write for it. D-1041

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

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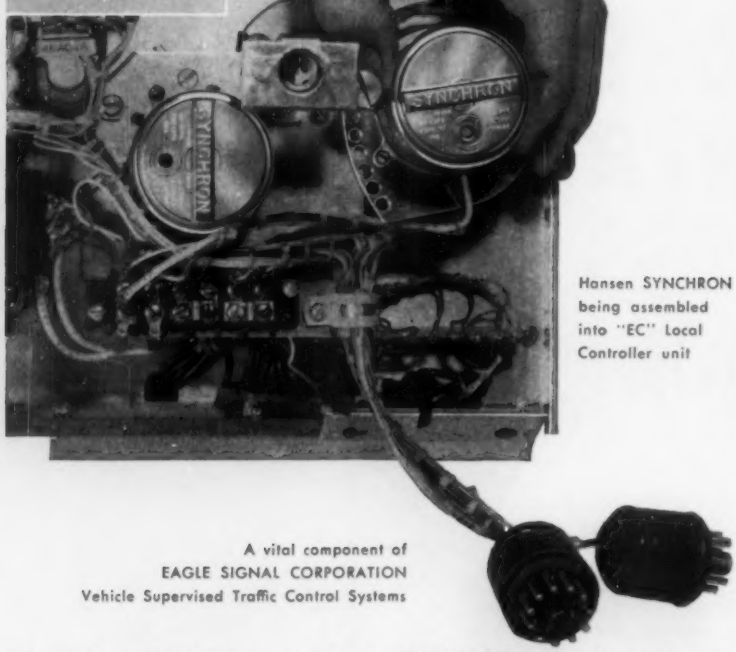
CIRCLE 421 ON READER SERVICE CARD 421

PRODUCT APPLICATION

HANSEN SYNCHRON TIMING MOTORS

TRAFFIC CONTROL systems



Hansen SYNCHRON being assembled into "EC" Local Controller unit

A vital component of EAGLE SIGNAL CORPORATION Vehicle Supervised Traffic Control Systems

EAGLE SIGNAL CORPORATION uses Hansen SYNCHRON motors for synchronous power to govern signal timing operations in "EC" Traffic Control Systems. Hansen SYNCHRON motors regulate amber and pedestrian clearing intervals — and all other intervals which remain *constant* regardless of cycle length . . . and also govern the 4 independent traffic splits (time division for vehicular traffic) — as well as any interval which is *variable* according to cycle length. The Hansen SYNCHRON, regulating constant intervals, operates on 60-cycle power supply . . . the one governing variable intervals responds to variable frequency from the master control unit.

HANSEN SYNCHRON TIMING MOTORS were chosen by Eagle Signal after careful testing of several makes of synchronous motors. Due to the size of some timing devices and control units, a small motor with good performance characteristics was needed to fit the space limitations. After extensive tests, Hansen SYNCHRON motors were specified for: (1) high-quality performance under test; (2) lower cost; (3) long-life operation as an integral part of traffic control units. Since adoption, Eagle Signal has never experienced an assembly slowdown or stoppage due to failure on service or delivery of Hansen SYNCHRON Timing Motors.

SEND TODAY for informative folder containing specifications and technical data on all Hansen SYNCHRON motors and clock movements.

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catalogs and bulletins.....continued

(H-116) Engines and Generators—Brochure, 4 pp. Gives construction, ratings of gasoline engines, generators, engine-generators, engine-compressors. D W Onan & Sons, Inc, 2515 University Ave SE, Minneapolis 14, Minn.

(H-117) Temperature Controls—Catalog, 8 pp. Provides descriptions, some prices and specifications of electrical, mechanical and pneumatic; indicating, non-indicating and recording types. The Partlow Corp, 294 Campion Rd, New Hartford, NY.

(H-118) Motors—Catalog, 8 pp. Gives operating curves for standard models up to 40 hp. Shows some special models. Ac and dc motors represented. Peerless Electrical Div, H K Porter Co, Inc, 1401 W Market St, Warren, Ohio.

(H-119) Temperature Controls—Bulletin, 8 pp. Rem. . . bulb controllers indicate or record. Temperature ranges from –110F to 600F. Control system uses compressed air. The Powers Regulator Co, 3490 Oakton St, Skokie, Ill.

(H-120) Temperature Control Transmitter-receivers—Bulletin, 4 pp. Pneumatic controls and transmitters control temperature in air conditioning and industrial processes. Diagrams sample systems. The Powers Regulator Co, 3490 Oakton St, Skokie, Ill.

(H-121) Fhp Motors—Catalog, 12 pp. Shows ac and dc motors and blowers plus several specialized related products. Redmond Co, Inc, Div of Control Co of America, 201 Monroe St, Owosso, Mich.

(H-122) Magnetic Chip Detectors—Catalog, 8 pp. Describes device to give warning of chip formation in engine. Magnets attract chips which bridge an air gap to complete an electrical circuit. Lisle Corp, 807 Main St, Clarinda, Iowa.

(H-123) Vibration Warning—Two bulletins, 8 pp. Explains devices designed to warn of impending failure when preceded by high frequency, low amplitude vibration or high amplitude vibration. Robertshaw-Fulton Co, A & I Div, Santa Ana Freeway & Euclid, Anaheim, Cal.

(H-124) Aircraft and Industrial Controls—Bulletin series, 45 pp. Shows oxygen control valves, liquid level sensors, indicators and recorders, crystal oven and others. Robertshaw-Fulton Controls Co, Aeronautical & Instrument Div, Santa Ana Freeway at Euclid, Anaheim, Cal.

(H-125) Pressure Transducer—Brochure, 4 pp. Explains operation and performance of force balance type available in different configurations for measuring several pressure dependent parameters. Servomechanisms, Inc, Los Angeles Div, 12500 Aviation Blvd, Hawthorne, Cal.

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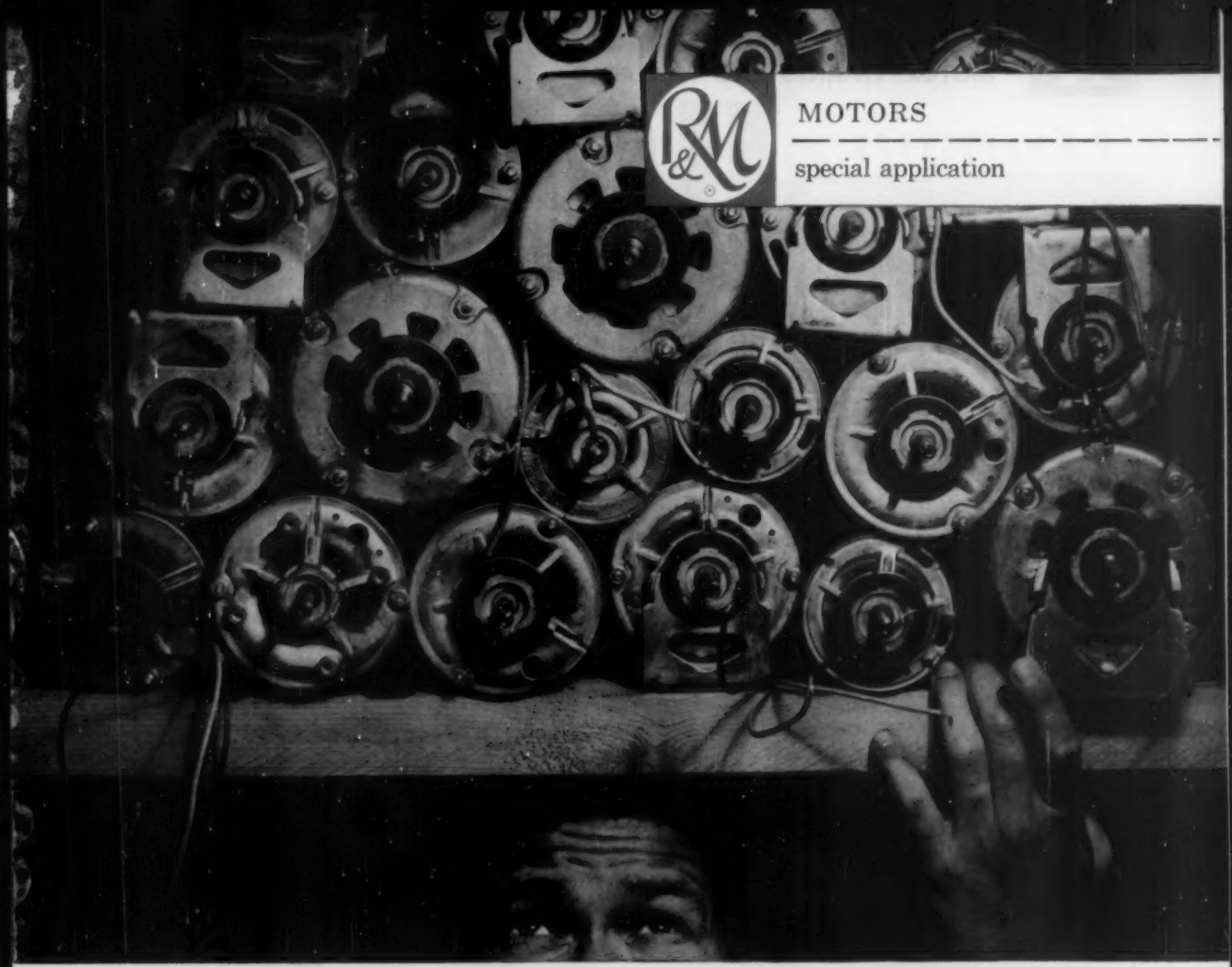
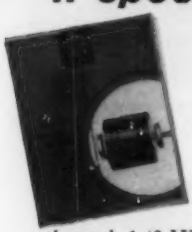


if special application FHP motors are on your mind... write for R&M's new Bulletin 445

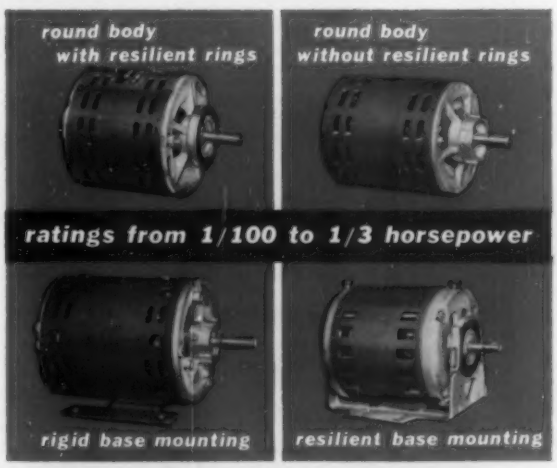


This informative bulletin illustrates and describes in detail Robbins & Myers broad new line of Special Application FHP Motors.

You may select from four frame sizes, sixteen ratings from 1/100 through 1/3 HP, three different pole constructions, three standard mounting arrangements and four electrical types.

Simple, compact and quiet, these motors offer built-in benefits for your customers, as well as design flexibility for you, where silent operation, limited mounting space and minimum attention are factors.

Also, should your requirements be so special that a custom designed motor is indicated, our expert application engineers, using the most modern electronic computers, can promptly select the optimum design for your special requirements. Write today for your copy of R&M's new bulletin 445PRE.


round body with resilient rings
round body without resilient rings
ratings from 1/100 to 1/3 horsepower
rigid base mounting
resilient base mounting

ROBBINS & MYERS, INC., Springfield, Ohio

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CIRCLE 423 ON READER SERVICE CARD

MOTOR, ENGINES AND CONTROLS

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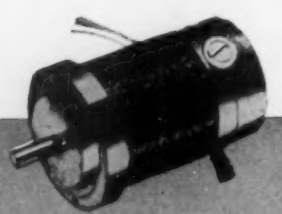
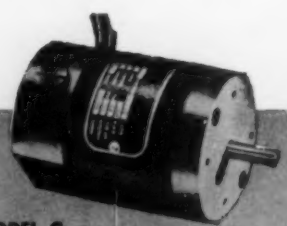
Howard alone offers such an all-inclusive line of Universal and D.C. motors—including over 65,000 specs on file for every conceivable application. With this vast source to draw from chances are there are specs on hand to meet your requirements. That's why Howard can provide the motor you need, more quickly and at lower cost. Shown here are just a few of the standard models in the Howard line. For complete information, samples and prices on these or other Howard Universal and D.C. motors—from 1/200th to 1 H.P.—send us your specifications today.

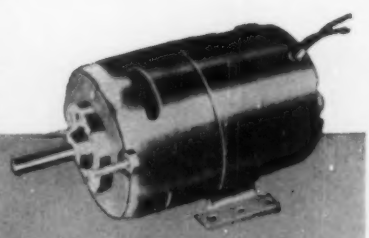
1/200th TO 1 H.P.— High Speed, High Starting Torque



MODEL B
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 1-11/16
LENGTH: 2-3/16 to 3-11/16
H.P.: Continuous 1/40
Intermittent 1/20
Full Load Speed—Series 5200 to 10,000 R.P.M.
Shunt — 1800 to 10,000 R.P.M.
VOLTAGES: Series — 6 to 115V, AC-DC
Shunt — 6 to 120V DC
BEARINGS: Precision grease sealed ball bearings.

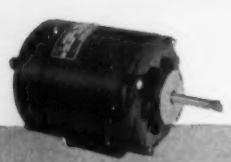


MODEL C
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 2-1/4
LENGTH: 2-9/16 to 3-9/16
H.P.: Continuous 1/25
Intermittent 1/12
Full Load Speed—Series 5200 to 10,000 R.P.M.
Shunt — 1800 to 10,000 R.P.M.
VOLTAGES: Series — 6 to 115V, AC-DC
Shunt — 6 to 120V DC
BEARINGS: Precision grease sealed ball bearings.

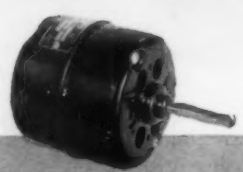


MODEL F
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 3-1/2
LENGTH: 4-1/8 to 5-11/32
H.P.: Continuous 1/2
Intermittent 3/4
Full Load Speed—Series 3800 to 10,000 R.P.M.
Shunt — 1800 to 10,000 R.P.M.
VOLTAGES: Series — 6 to 115V, AC-DC
Shunt — 6 to 120V DC
BEARINGS: Precision grease sealed ball bearings.

MODEL 243
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-17/32.
LENGTH: 3-15/16.
H.P.: Continuous Series—1/12 @ 10,000 R.P.M.
Intermittent—1/8 @ 10,000 R.P.M.
SPEED: Full Load Speed:
Series—5000 to 10,000 R.P.M.
Shunt—2000 to 7000 R.P.M.
VOLTAGES: Series—12 to 230V. AC/DC.
Shunt 6 to 120V. DC.
BEARINGS: Porous bronze self aligning type with oil reservoir.



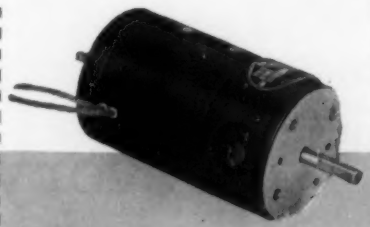
MODEL 29-500
TYPE: Universal AC/DC or Shunt.
DIAMETER: 3-5/16.
LENGTH: 4-11/16 to 5-19/32.
H.P.: Continuous: Series—1/6 @ 10,000 R.P.M.
Shunt or Compound—1/12
Intermittent Series—1/4 @ 10,000 R.P.M.
Shunt or Compound—1/6.
SPEED: No Load: Series—15,000 R.P.M.
Shunt or Compound—12,000 R.P.M.
Full Load Speed: Series—3000 to 10,000 R.P.M.
Shunt or Compound—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 250V. AC/DC.
Shunt or Compound—6 to 230V. DC.
BEARINGS: Porous bronze sleeve type or grease sealed ball bearings.



MODEL 11A
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2.825".
LENGTH: 3-9/16".
H.P.: Continuous 1/75.
Intermittent: 1/20.
SPEED: No Load Speed: Series — 15,000 R.P.M.
Shunt — 3500 to 12,000 R.P.M.
Full Load Speed: Series — 3000 to 10,000 R.P.M.
Shunt — 2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 115V. AC-DC.
Shunt — 6 to 120V. D.C.
BEARINGS: Porous bronze self aligning type with felt oil reservoir.

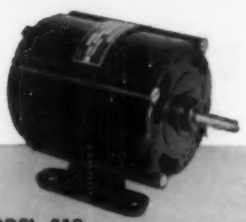
COMPLETE LINE OF UNIVERSAL & DC FRACTIONAL H.P. MOTORS

MODEL 11-12
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-25/32". 2-9/32" flat side.
LENGTH: 4-19/32".
H.P.: Continuous Series—1/15 @ 10,000 R.P.M.
Shunt—1/20.
Intermittent: Series—1/6 @ 10,000 R.P.M.
Shunt—1/8.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—3500 to 10,000 R.P.M.
Full Load: Series—5000 to 10,000 R.P.M.
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze self aligning type with felt oil reservoir, or grease sealed ball.

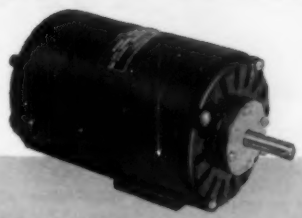


MODEL 106
TYPE: Series or Shunt DC only.
Diameter: 2-5/16".
LENGTH: 3.89". 3.85".
H.P.: Continuous: Series—1/35 @ 10,000 R.P.M.
Intermittent: Series—1/10 @ 10,000 R.P.M.
Shunt—1/10.
SPEED: Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt—1800 to 10,000 R.P.M.
VOLTAGES: Series—6 to 120V. DC.
BEARINGS: Grease sealed ball bearings.

MODEL 200
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 1-11/16".
LENGTH: 2-11/16".
H.P.: Continuous Series—1/200 @ 10,000 R.P.M.
Shunt—1/200.
Intermittent: Series—1/75 @ 10,000 R.P.M.
Shunt—1/75.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—15,000 R.P.M.
Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt—3000 to 10,000 R.P.M.
VOLTAGES: Series—6-115V. AC/DC.
Shunt—6 to 32V. DC.
BEARINGS: Grease sealed ball bearings.



MODEL 512
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 3-3/8". LENGTH: 4-3/4".
H.P.: Continuous Series—1/10 @ 10,000 R.P.M.
Shunt—1/12.
Intermittent: Series—1/3 @ 10,000 R.P.M.
Shunt—1/6.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: 5000 to 10,000 R.P.M.
Shunt: 1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type.



MODEL 700
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 3.900".
LENGTH: 5-7/64". to 6-7/64".
H.P.: Continuous: Series—1/4 @ 10,000 R.P.M.
Shunt—1/8.
Intermittent: Series—1/2 @ 10,000 R.P.M.
Shunt—1/4.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: Series—5000 to 10,000
Shunt—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 115V. AC/DC.
Shunt—6 to 230V. DC.
BEARINGS: Grease sealed ball bearings.

MODEL 1100
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-13/16". LENGTH: 3-9/16".
H.P.: Continuous: Series—1/50 @ 10,000 R.P.M.
Shunt—1/50.
Intermittent: Series—1/15 @ 10,000 R.P.M.
Shunt—1/15.
SPEED: No Load: Series—15,000 R.P.M. approx.
Shunt—3500 to 12,000 R.P.M.
Full Load: Series—3000 to 10,000 R.P.M.
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type, or Grease Sealed Ball Bearings.

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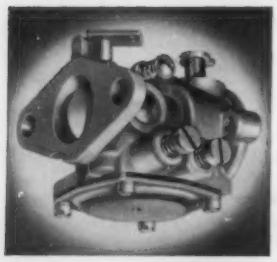

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CARBURETOR

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Simple, float-type with easy-to-read legend. Handy accessory that solves major mowing problem. Four sizes to fit all engines.

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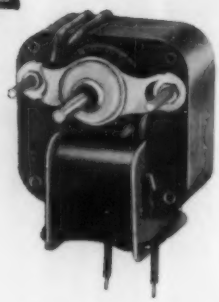
Engine Plants: Grafton, Wisc. — New Holstein, Wisc.

426 CIRCLE 426 ON READER SERVICE CARD

BREVEL



This shaded pole motor is available as a high speed motor alone or as the backbone of BREVEL's quality gear motors.

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Your new products get into production — and to market — faster, at lower cost when BREVEL supplies your motors. Chances are we have a suitable design! You can rely on BREVEL's experienced specialization to design, engineer, and volume-produce precision motors that give consistently superior service at low cost.

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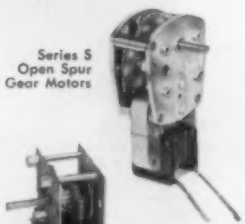

Series S
Open Spur
Gear Motors

Series W
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Series F
Enclosed Helical
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CHICAGO: Jerry Golten Co. • 2750 W. North Ave. • EVergiade 4-5959
LOS ANGELES: Electric Motor Engineering, Inc. • 8255 Beverly Blvd. • OLive 1-3220
IN CANADA: Brevel Products, Ltd., 45 Crockford Blvd., Scarborough, Ont., PL 7-5140

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catalogs and bulletins.....continued

(H-126) Miniature Metal Bellows—Bulletin, 4 pp. Gives engineering information, formulas and chart for computing and specifying any design. Suggests applications. Servometer Corp, 222 Main Ave, Passaic, NJ.

(H-127) Gasoline Fuel Injection Systems—Brochure, 8 pp. Describes operation of components and system. Includes diagram and curves. Simmonds Aerocessories, Inc, 105 White Plains Rd, Tarrytown, NY.

(H-128) Fractional Hp Motors—Catalog, 8 pp. Provides dimensions, ratings and other data on motors, blowers, generators, tachometer generators. Small Motors, Inc, 2076 Elston Ave, Chicago 14.

(H-129) Ac Motors—Bulletin, 16 pp. Gives electrical and construction details on single phase and polyphase induction and synchronous motors from ¼ to 800 hp. A O Smith Corp, Electric Motor Div, 531 N Fourth St, Tipp City, Ohio.

(H-130) Gas Turbine Engines—Brochure, 24 pp. Describes engines from 80 to 1250 hp at 75F. Both axial and centrifugal compressors and turbines used. Some will burn gas. All will burn a variety of liquids. Solar Aircraft Co, 2200 Pacific Hwy, San Diego, Cal.

(H-131) Photoelectric Controls—Catalog, 11 pp. Describes basic units and accessories for counting and control. Standard Instrument Corp, 657 Broadway, NYC.

(H-132) Synchronous Motors—Bulletin, 12 pp. Presents ratings, specifications and technical data for 50, 150 and 250 oz-in. models. Describes uses as dc stepping motor. The Superior Electric Co, 83 Laurel St, Bristol, Conn.

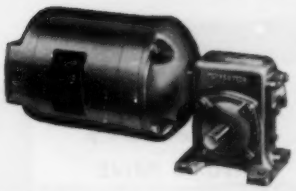
(H-133) Pressure Regulator—Bulletin, 4 pp. Describes a straight through flow pressure regulator for gas, liquid or chemical service at inlet pressures to 1400 psig. Apco, Div of Textron Inc, 616-E W Whittier Blvd, Whittier, Cal.

(H-134) Photoelectric Components—Brochure, 4 pp. Describes miniature and subminiature probe type photoelectric pickups and light sources plus photoelectric controllers. Also shows photoelectric relays and proximity pickups and relays. Tri-Tronics Co, 2607 St Charles Rd, Bellwood, Ill.

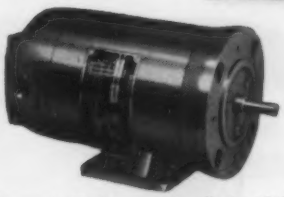
(H-135) Ac Motor—Bulletin, 7 pp. Describes standard types, gearmotors, variable speed drives and special purpose motors. US Electrical Motors, Inc, 200 E Scauson, Los Angeles.

(H-136) Flow Meters—Bulletin, 6 pp. Shows construction, dimensions of meters for air and other gases for capacities to 25,000 cfh. Waukee Engineering Co, Inc, 5150 N 34 St, Milwaukee, Wisc.

continued



Typical Doerr-Perfection gearmotor. Offered in five sizes, in ratings from 1/20 to 1 HP. High torque capacities. Flange and vertical mountings available.



Compact 42 frame motor (only 4¾" diam.) in ratings to 1 HP.; all types and enclosures; single and dual voltage. Motor shown has both rigid base and NEMA Type C face mounting.

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Over 95% of Doerr's production consists of motors with one or more special features

Rely on Doerr's long and specialized experience to solve your problems. List your specifications. Then let Doerr prove how easy it is to select and receive on-time delivery of motors that *exactly* fill your need.

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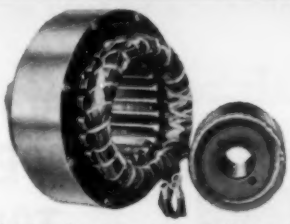
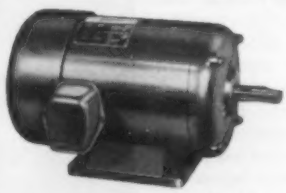
Discover now why leading machinery builders consistently reorder Doerr Motors. Before you buy, just write or call us in for a talk. More than likely we can furnish the top-quality power package you want. Try us, and see.



Special diameter motor parts for use in rotary oil burners. Range ½ to 5 HP.

Doerr motor with special mounting used on leading 10" table saw.

Sanitary dairy pump motor... Doerr-Designed to customer's specifications.



Doerr motors are now offered in ratings up to 15 HP. Motor shown above is 5 HP., 215 frame, totally enclosed, fan-cooled.

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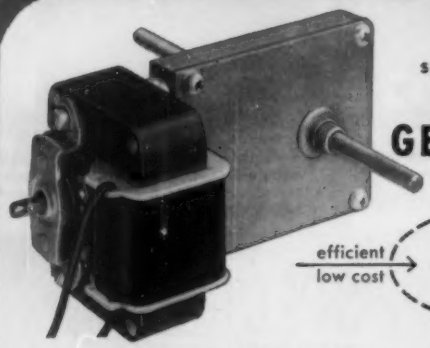

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sub-fractional h.p.
WORM DRIVE
GEAR MOTOR
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efficient / low cost → exceptionally QUIET operation

A two-pole, shaded pole AC induction motor with totally enclosed die cast gear-reducer. Available for 6 to 220 volts, 50 or 60 cycle AC. Gear-reducer speeds, ½ to 300 rpm. Output torque up to 50 inch lbs. at ½ rpm. Precision worm drive. Output shafts, 3/16", ¼", 5/16", ⅜". Mounts in any position. Ideal for motorized office equipment, revolving displays, vending machines, remote TV tuning, etc. Optional: solenoid brake for fast stopping; overload thermal protection; varnish impregnated stator; stainless steel or plated shafts.

We custom-design motors up to 1/40 h.p.; 6 to 220 v., 50 or 60 cycle; ½ to 800 rpm.; torque up to 200 inch lbs. Special gear-reducers designed to your requirements at low cost. Send for details.

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Custom Designers and Manufacturers of Sub-Fractional Horsepower Motors and Gear-Reducers

CIRCLE 665 ON READER SERVICE CARD

catalogs and bulletins.....continued

(H-137) Engine Controls—Bulletin, 4 pp. Explains operation of system for manual or automatic control by mechanical, electrical or electronic signal. Waukesha Motor Co, W St Paul Ave, Waukesha, Wisc.

(H-138) Ac Magnetic Starters—Brochure, 8 pp. Describes construction, operation and maintenance of motor starters. The Clark Controller Co, 1146 E 152 St, Cleveland.

(H-139) Two-stroke Engines—Brochure, 4 pp. Gives power and torque curves and specifications of engines rated from 1.6 to 5.0 hp. West Bend Aluminum Co, Hartford, Wisc.

(H-140) Two-stroke Kart Engines—Brochure, 4 pp. Engine with 5.8 cu in. displacement delivers over 4 hp @ 6000 rpm; 7.0 cu in. engine, over 5 hp @ 6000 rpm. West Bend Aluminum Co, Hartford, Wisc.

(H-141) Control Pushbuttons, Relays, Pilot Devices—Catalog, 130 pp. Presents descriptive and applications data for a complete line of manual and magnetic motor controls. Standard Control Div, Westinghouse Electric Corp, Beaver, Pa.

(H-142) Heat Transfer System—Brochure, 8 pp. Describes oil circulating system for heating platens, rolls, mills and applicators. Youngstown Miller Corp, 191 Woodlawn Ave, Norwalk, Ohio.

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NEG'ATOR spring motors can solve many "mechanical drive" problems. They provide more turns than any other spring motor, give constant torque output, are powerful and compact, will not "jump" or skip. Order one for experimental purposes. See table below for stock models and prices.

Model No.	Spring Torque in Lb.-in.	Cable Tension in Lbs.	No. Revolutions	Cable Length in In.	Endurance (Min. No. Cycles)	Price
P7172	.1	0.375	20	36	3,000	$5.00
A2025-1	.78	1.0	15	72	7,500	8.00
A2025-2	1.56	2.0	15	72	2,500	8.00
A2025-3	2.33	3.0	15	72	4,500	12.00
A2025-4	3.12	4.0	15	72	2,500	12.00
A2025-5	3.90	5.0	15	72	2,000	12.00

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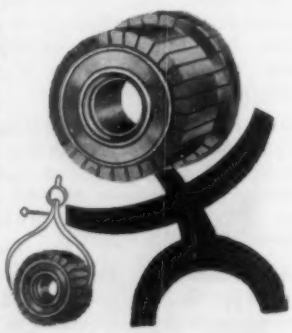

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SECTION I

ELECTRICAL AND ELECTRONIC COMPONENTS

Design Abstracts 430

10 X-ray Methods
by Vern W. Palen 432

How Information is Presented on Cathode-ray Display Tubes
by Richard A. Barker 434

Fundamentals of Slip-ring Assemblies 439

For Inspection and Decision Making, Electronic Gaging
by David R. Houck 440

16 Ways to Apply Limit Switches 442

Semiconductors Compared 445

DESIGN ABSTRACTS

6 TRANSDUCERS FOR POSITIONING

The increased sophistication of numerical control systems users has cleared up the early misunderstanding that a precise control alone could make up for inherent faults of the machine. Now fully aware of their responsibilities in gaining accuracy objectives, machine builders are steadily improving the art of mechanical design. But they are making things harder for the control engineer. With the machine builder now really able to use high electrical accuracies, control engineers may have to upgrade their systems. Top attention must be given to the position measuring transducer, since it sets the accuracy limits of the feedback loop. Six high-precision transducers with measurement capabilities up to one part in a quarter million are described. Types described and illustrated are: Pin-and-paul mechanism, magnetic bench-mark system, resolver-type transducers, electrostatic discs, coded-disc transducer, diffraction gratings.

"6 Transducers for Precision Position Measurement," John O. Morin, Concord Control, Inc. Control Engineering, May 1960, 330 West 42nd Street, New York 36.

*

Thermoelectricity

A review of past, present and future developments is presented. Some modern products depending upon thermoelectricity are illustrated.

"A Ray From the Brighter Tomorrow . . . Thermoelectricity," Capt. Norbert Frankenberger, USN, and Lt. John C. Cooper, USN. Bureau of Ships Journal, April 1960, Bureau of Ships, Dept. of the Navy, Washington 25, D C.

*

Silicon Capacitors

Highly complex equipment of the present day may use tens of thousands of components in one system. It is becoming increasingly vital to keep the size and weight of these components as small and as reliable as possible. To achieve this aim, it often is not sufficient merely to improve the design of existing components. It is often desirable to make radical departures in the basic design and principle of the components.

An example of such a radical departure from conventional basic design is the silicon capacitor, a device which not only fulfills the function of a conventional variable air capacitor, but does so on an entirely different and until recently unused principle.

"Circuit Design Using Silicon Capacitors," J. Hammersla, Semiconductor Div, Hughes Products, Newport Beach, Calif. Electronics, Sept 18, 1959, 330 W 42nd St, New York 18, New York.

*

Magnetic Flow Measurement

Fluid-flow measurement by magnetic induction is simple in principle, but gives rise to some quite difficult practical problems, which are discussed. The worst of these is due to the presence of variable out-of-phase components in the ac signal. This difficulty can be overcome by the use of feedback quadrature suppression, and a system is described which uses a suppressor containing only transistors, thermistors and other solid-state electronic components.

"Some Problems of Magnetic Flow Measurement," I. C. Hutcheon, Research and Development Dept, George Kent Ltd. Instrument Engineer, April 1960, George Kent Ltd, Luton, Bedfordshire, England.

*

Thermoelectric Refrigeration

Thermoelectric semiconductor materials, products of semiconductor research, have converted an old phenomenon, thermoelectricity, from a laboratory curiosity to a potential, practical source of electric power, or of refrigeration. Recent progress in materials has made it possible to construct thermoelectric generators with cooling capacities of up to several hundred Btu per hour.

Establishment of practical thermoelectric cooling fills a gap, in regard to capacity, in refrigeration systems. Vapor compression systems have a lower practical capacity limit of approximately 100 Btu per hour. Other refrigeration systems, such as vapor absorption, suffer disadvantages which limit their use in applications requiring less than 100 Btu per hour.

The number of applications within this low cooling capacity range are increasing rapidly and in importance. This is particularly true in the electronics industry. Medicine and its related sciences represent another important field of application for thermoelectric cooling. The oil and food industries are additional potential fields of application.

Small size, simplicity, and reliability of thermoelectric coolers further enhance their potential use. These advantages as well as the growing field of application for thermoelectric refrigeration is illustrated by describing several thermoelectric refrigeration devices. The majority of the applications described are primarily for use in electronic equipment or by scientific laboratory, hospital, or related environment. Brief mention is made of two other interesting thermoelectric cooling projects: the development of a 1-ton shipboard air conditioner and an air-conditioned personnel garment.

"Thermoelectric Refrigeration," W. L. Wright, Westinghouse Electric Corp, Pittsburgh, Pa. Electrical Engineering, May 1960, 33 W 39th St, New York 19, New York.

*

Solenoid-valve Capacity

These methods of specifying solenoid-valve capacity are discussed: max pressure drop; min pressure required; coefficient of flow; equivalent orifice. In some cases, some relevant curves and equations are included.

"How to Specify Solenoid-valve Capacity." Design Engineering, May '60, 481 University Ave, Toronto 2, Canada.

*

Image Quality and Information

Experiments conducted to determine relation between quality of transmitted image and the amount and quality of information obtainable

from it are described. A technique for evaluating the usefulness of various quality imagery is under development. Much work remains to be done, particularly in the areas of subjective analysis as opposed to form recognition.

"Image simulation and Interpretation," G. L. Meyer, Astro-Electronic Products Div, Radio Corp of America, Princeton, NJ.

*

Load Cell Weighing Systems

Load cells—resistance strain-gage force-measuring transducers—are useful components in the design of high-accuracy electronic weighing systems. Practical advantages include their small size and easy adaptation in existing structures. Moreover, they can be hermetically sealed against their environment. Reasonable shock loads will not damage load cell weighing systems because there are no pivots, knife edges, or moving parts.

"Using the Load Cell in High-accuracy Weighing Systems," Malcolm Green, Bytrex Corp. Control Engineering, October 1959, 330 W. 42nd Street, New York 36, New York.

*

Photoelectric Cell for Measuring

Applications and design of cells are discussed and an extensive bibliography provided. Topics covered include galvanometric measurement, photometry with unanalyzed light, spectral photometry and calorimetry, absorption and blackening measurements, polarimetry and optical crystallography.

"The Photoelectric Cell as a Measuring Instrument," Rudolf Sewig. Transaction of Zeitschrift fur Instrumentunde (West Germany). Translations available from Special Libraries Assn Translation Center, John Crerar Library, 86 E Randolph St, Chicago 1.

*

Ultrasonic Measurement of Corrosion

A method of making nondestructive thickness measurements from one side on steel, using an ultrasonic gage, is described. Accuracy of the "slide rule" method of calibration is detailed, the various sources of error examined, and means of compensating for them explained. Merits of the cathode-ray-tube resonance instrument are explained, and its efficiencies over earlier instruments outlined.

New techniques developed during experience in recent years are described and some changes in attitude toward earlier accepted procedures explained. Manner in which data are recorded is shown in tables.

"Ultrasonic Measurement of Tank Ship Corrosion Losses, D. J. Evans, Engineering Test Services, Inc. Corrosion, Nov 1959, 1061 M&M Bldg, Houston 2, Nov '59.

*

Fuel Cells

Recent developments in the field of fuel cells are described. These devices are capable of converting the chemical energy of fuels directly into electric energy. It is predicted that fuel cells for central station power may become a reality in the future.

"Advances in Basic Sciences 1. Fuel Cells," D. L. Douglas, General Electric Research Laboratory, Schenectady, New York. Electrical Engineering, Sept 1959, 33 West 39th St, New York 18, New York.

*

Digital Actuators

The growing importance of digital techniques for computation and control has led to the introduction of a complete line of digital actuators. These actuators can be operated directly from digital computers, digital-type remote control stations, or programmers. Seven types are illustrated.

"Digital Actuators," T. Gizeski, Ferguson, Hille & Associates, Inc. Instruments and Control Systems, November 1959, 845 Ridge Avenue, Pittsburgh 12, Penna.

*

Thermoelectric Concepts for Engineers

Most engineers have studied the first and second laws of thermodynamics (relating to the conservation of energy and the production of entropy). However, these are insufficient for understanding the concepts in the simultaneous flow of electric current and heat, the basis of applications of this new type of power package.

Thermoelectric concepts are presented in terms of simultaneous equations involving current and heat flows. Although the explanations given do not entirely fit the physical conditions of thermoelectric materials used in practice, they should meet immediate needs of most interested engineers.

"Thermoelectric Concepts for Engineers," Milnes and Alfonso, Carnegie Institute of Technology; AIEE paper CP 60-173. American Institute of Electrical Engineers, 33 W 39th St, New York 18.

*

Trends in Electron Devices

Electron device technology keeps advancing both in new devices and improvements to existing ones. Researchers have developed more versatile storage and display devices, and smaller cathode-ray tubes. New design techniques are leading to improved performance from traveling wave tubes, parametric amplifiers and secondary emission multiplier tubes. Included is information on: Selective erasure tube, electroluminescence, logic elements, reflected-beam kinescope, parametric amplifier, traveling-wave paramps, multiplier tube, low-noise devices.

"Latest Trends in Electron Devices," Michael F. Wolff, Assistant Editor. Electronics, December 25, 1959, 330 W 42nd St, New York 36, New York.

*

Selecting Transistors

Nuclear radiation effects are becoming important in design so equipment that can survive a nearby nuclear burst is now being considered. With future prospects of nuclear aircraft, equipment must also be able to operate for a long time near radiation.

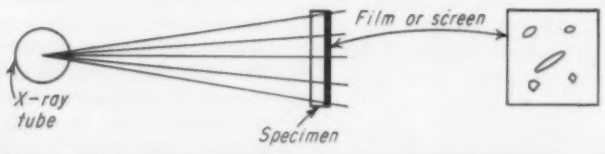
"Selecting Transistors for Radiation Environments," John R. Bilinski and Richard Merrill, General Electric Co, Ithaca, New York. Electronics, December 25, 1959, 330 W 42nd St, New York 36, New York.

From: American Machinist/Metalworking Manufacturing

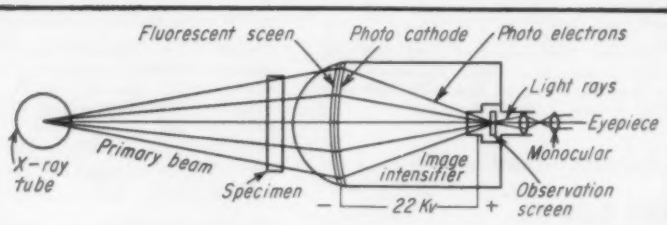
10 X-RAY METHODS

VERN W PALEN
Philips Electronic Instruments
Mount Vernon, N. Y.

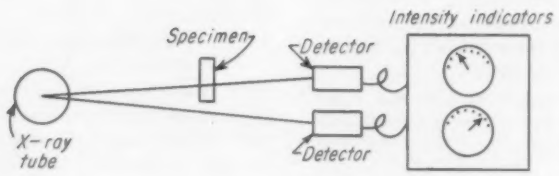
Diagrams of x-ray setups for inspecting, measuring and analyzing.



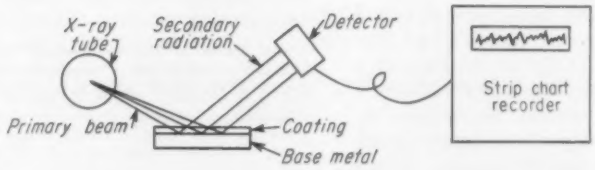
1. INDUSTRIAL RADIOGRAPHY AND FLUOROSCOPY
Equipment checks internal physical structure of many materials. Spots on films indicate voids or other density variations. High voltage X-ray units produce "hard" radiation needed to penetrate thick specimens.



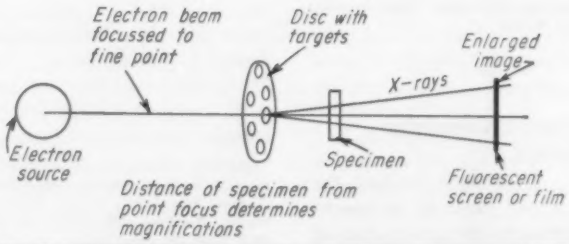
2. INDUSTRIAL FLUOROSCOPY WITH IMAGE INTENSIFIER
Used for inspection of steel welds, heavy rubber sections, honeycomb, thick plastic parts, ordnance materials, homogeneity of fuel elements.



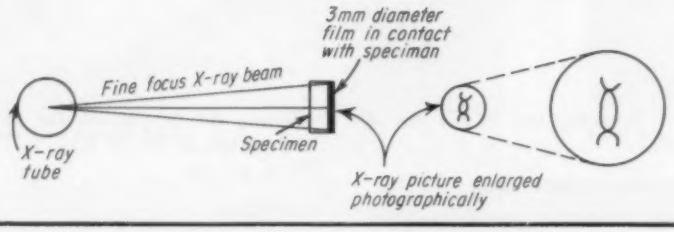
3. X-RAY ABSORPTION
Instrument compares direct intensity from X-ray tube with that remaining after passing through specimen. The ratio of the two readings determines chemical composition by applying laws of X-ray absorption.



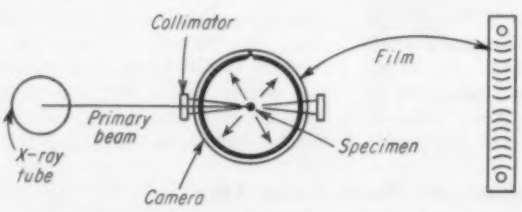
4. X-RAY FLUORESCENCE ABSORPTION
Instrumens used for measuring tin coating on steel plate and other similar applications. Primary beam causes base metal to fluoresce. Secondary rays are partially absorbed by coating. Detected intensity remaining is a measure of coating thickness.



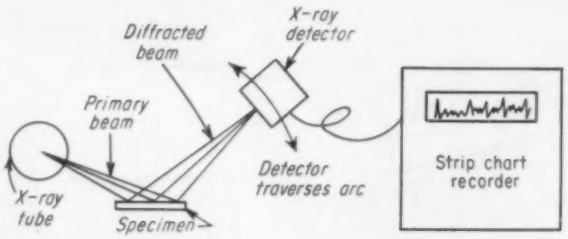
5. PROJECTION MICRORADIOGRAPHY (X-ray Microscopy)
For critical evaluation of opaque specimens. By choice of different targets during operation, stereo micrography and absorption analysis are handled on this instrument. An adjunct to light and electron microscopy.



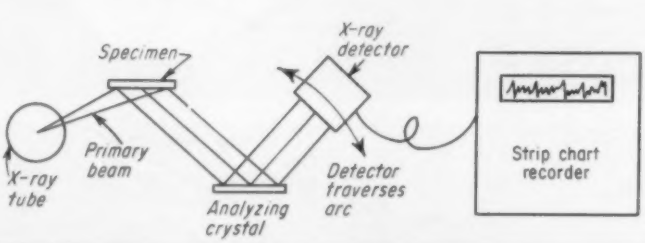
6. CONTACT MICRORADIOGRAPHY
For examining opaque minute specimens for microscopic detail. Small table unit employs 5kv or less to produce "soft" X-rays needed to work on thin foil specimens.



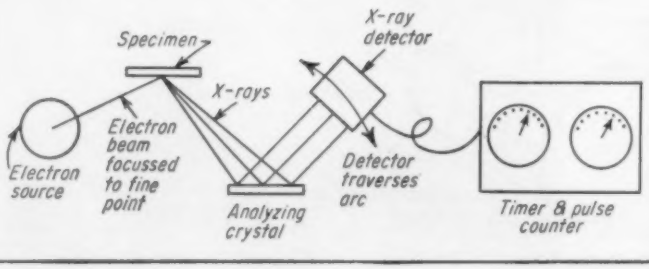
7. X-RAY DIFFRACTION
Analyzes for all chemical compounds such as inorganic salts. Each substance produces a different X-ray "fingerprint." Curved lines are produced on film by X-rays diffracted by atoms in specimen.



8. X-RAY DIFFRACTOMETRY
Analyzes for all chemical compounds such as inorganic salts. Same principle as diffraction except film replaced with detector and chart to give faster, more accurate data. Eliminates film processing and measurement.



9. X-RAY SPECTOGRAPHY (FLUORESCENCE)
Analyzes for elements in atomic range from No. 12 (magnesium) to No. 98 (californium). Automatic X-ray spectograph is available for production line control with strip chart replaced with printout console. Results are printed on tape for as many as 24 elements as fast as samples are inserted.



10. ELECTRON MICROBEAM PROBE
For qualitative and quantitative analysis of specimen surface in one cubic micron area. Used with optical microscope for studying varying composition in localized regions. Specimen acts as target and gives off X-rays from spot. Electromechanical devices provide motion for scanning the specimen.

REFERENCE:
X-ray Methods by Vern W. Palen, Philips Electronic Instruments, Mt Vernon, N. Y. Published in American Machinist, Feb. 8 '60, p. 143.

From: Control Engineering

how information is presented on . . . CATHODE-RAY DISPLAY TUBES

RICHARD A. BARKER *Stavid Engineering, Inc.*

The need for dynamic display—the exhibit of information which continually changes, sometimes at high rates of speed—has revealed certain limitations of older display techniques. These limitations can be broadly summarized as deficiencies in one or more of the following respects: Size, brightness, currentness, freedom from objectionable psychological effects, resolution, quantity of information presented, and pictorialism. Not all the older display approaches are deficient in all of these categories, nor do the newer dynamic display techniques fully satisfy all seven. The newer dynamic display techniques generally improve upon one or more of these limitations.

Because so many of the applications for dynamic information are associated with electronic systems—air traffic control,air defense, battlefield surveillance, and high speed data processing—considerable effort has been expended on making the cathode tube a more useful display device. These efforts have resulted in improvements in: Character generation tubes; direct view storage tubes; scan conversion tubes; color tubes; special function tubes.

Some of the newest and most promising techniques are tabulated in this article. Some are still in the development stage.

CHARACTER GENERATION TUBES

To identify symbolically as well as display information, character generation tubes have been developed, such as the Charactron. These are tubes that can generate one or more alphanumeric characters by passing an electron beam through an appropriately shaped aperture.

The Typotron combines character presentation with storage; the Compositron has a changeable font; and the Indicoder displays a limited number of characters (up to 12) one at a time.

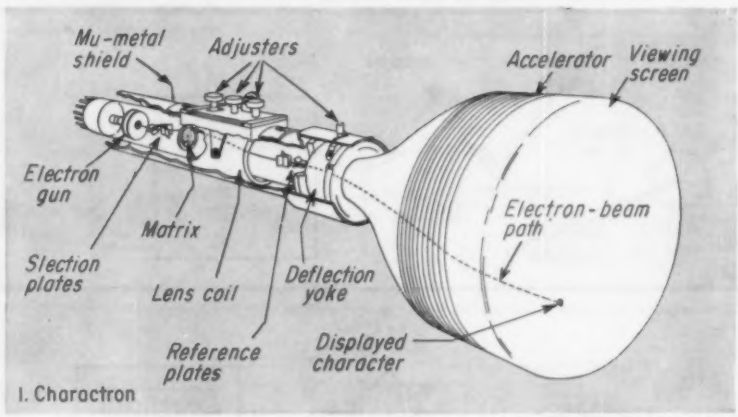
DIRECT VIEW STORAGE TUBES

Long persistence phosphors, re-excited at a slow rate, do not stay bright long enough for many applications. The direct view storage tube offsets this deficiency by continuously re-exciting the tube face. A "write" electron gun registers intelligence on a storage mesh. A "flood" electron gun then excites a phosphor screen following the pattern on the mesh. Writing speeds are as high as 300,000 in. per sec.

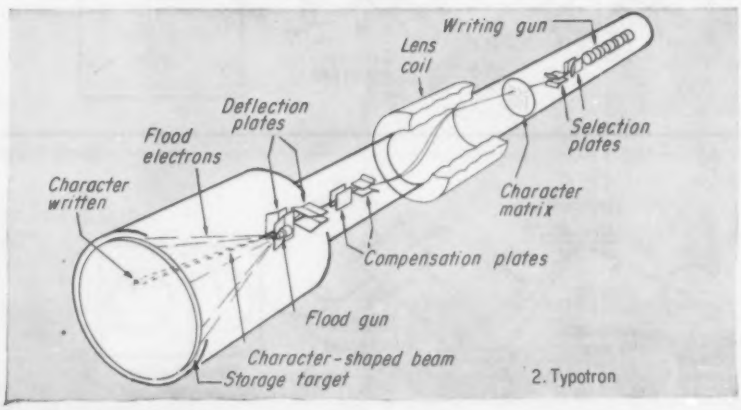
COLOR TUBES

The use of color in displays offers one of the most promising ways of gaining another variable display parameter. For example, it might be possible to display radar blips representing aircraft at another altitude in a second color, etc. Many color tubes under study were developed for en-

Here's What Some of Them Look Like

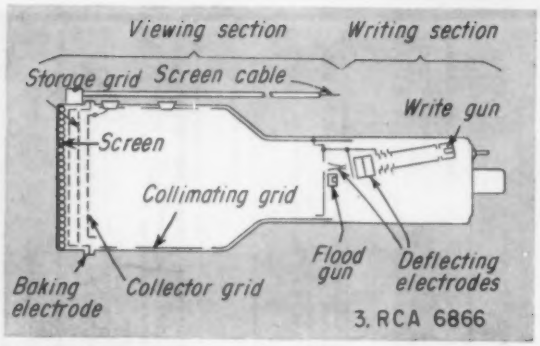


1. Charactron

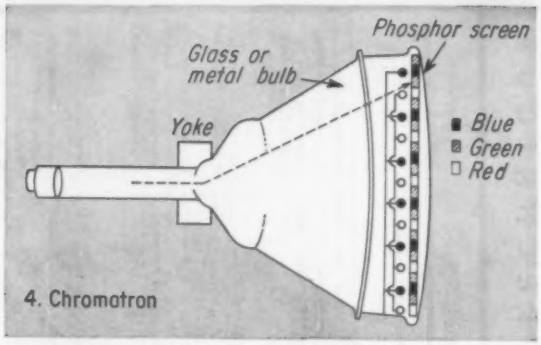


2. Typotron

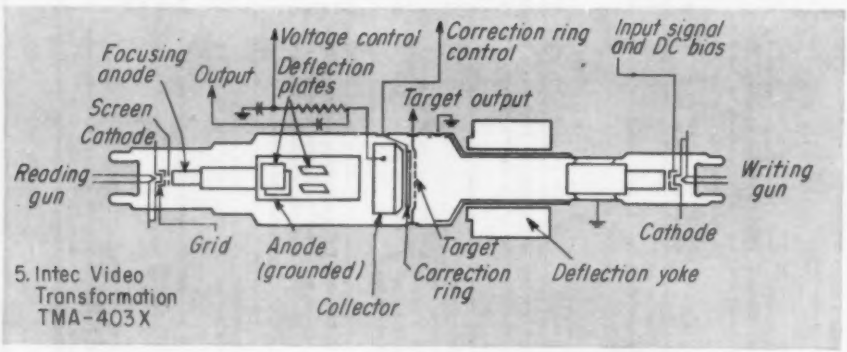
Character Generation Tubes



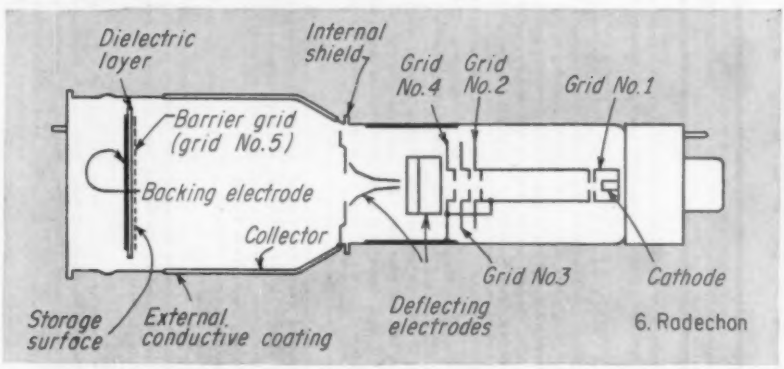
Direct View Storage Tube



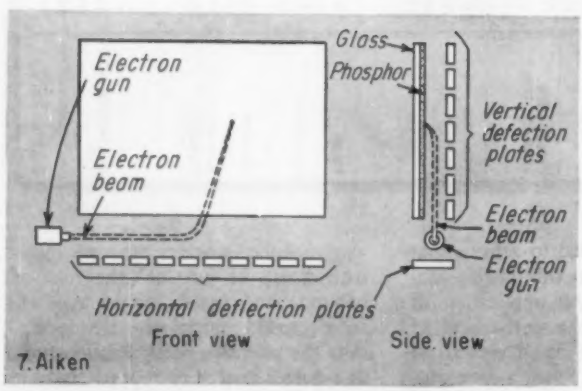
Color Tube

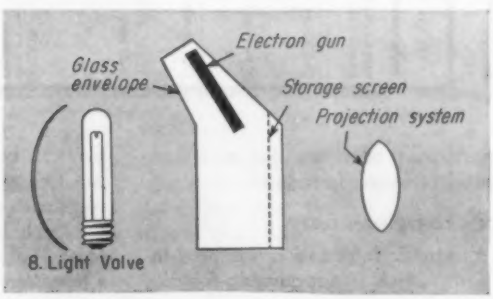


Scan Conversion Tubes



Special Tubes





CATHODE RAY TUBE DYNAMIC DISPLAY TECHNIQUES

TYPE OF DISPLAY	KEY FEATURES	APPLICATIONS	ADVANTAGES	LIMITATIONS	SUPPLIER
CHARACTER GENERATION TUBES	Identification as well as display of information by this cathode ray tube which can present one or more numeric, alphabetic, or alphanumeric characters at the same time. Generation can be by raster scan, Lissajous, or the shaped beam.				
Charactron	The tube has a 19-in. screen and is used for visual displays. The heart of the tube is the beam-forming matrix; there are 64 characters arranged in an 8 by 8 format. Tube with 17-in. diameter usable face costs about $1,600. (See figure 1.)	Can display alphanumeric symbols and analog data concurrently. In most applications a display rate of approximately 10,000 characters per sec is used. Depending upon the system parameters, a rate up to 20,000 characters per sec is attainable.	The choice of characters is essentially unlimited. Only one character is generated at a time. Hence, any character may be positioned at any point on the screen.	At speeds higher than 20,000 characters per sec component limitations destroy the display usefulness.	Stromberg-Carlson Div. General Dynamics (Similar tube made by Machlett Laboratories.)
Compositron	Has changeable font.	Characters are displayed in luminous form for photographing. Output device in data processing system.			Radio Corp. of America
Indicoder	Can present 12 characters (numerals zero through nine, plus and minus sign). Displays are 1 in. high, discernible at a distance of 20 ft.	Displays a limited number of characters, one character at a time. Converts binary-coded digital words directly into a visual numerical display.	Small size, rectangular face; can be stacked in any desired pattern. Several hundred tubes can be operated in parallel by a common set of high voltage power supplies. No intermediate amplifiers required.	Can present only 12 characters.	Stromberg-Carlson Div. General Dynamics
Typotron	Combines shaped beam techniques of Charactron tube and storage technique of Memotron (see below). Character height is 1/8 in. Writing speeds are as high as 25,000 characters per sec. Resolution is 200 to 240 lines. (See Figure 2.)	Can display alphanumeric information at any location on the tube face, retain it indefinitely and erase it at command.			Hughes Aircraft Co. (Similar tube made by Machlett Laboratories).
DIRECT VIEW STORAGE TUBES	Developed to circumvent the unsatisfactory brightness characteristics of long persistence phosphors. Intelligence is deposited on a storage mesh by a "write gun" at relatively slow rates; a "flood gun" provides a continuous stream of low velocity electrons which excite the phosphor screen in the pattern of the charges deposited on the storage mesh.				
RCA 6866	Available with selective erasure. Three to four halftones can be reproduced; resolution is 400 lines at center. (See Figure 3.)	Developed as a bright indicator for airborne search radar applications. No deterioration in brightness for a period of 10 sec, and a satisfactory display can be maintained for 60 sec after writing has ceased.			Radio Corp. of America
Iotron	Available in two all-magnetic forms, and in an all-electrostatic direct view tube. Electrostatic focusing reduces resolution by 25 percent.	Writing speed between 10,000 and 100,000 centimeters per sec.	Offers controllable persistence (from 1 millisec to several minutes) and at least four discernable levels of brightness for halftones.		Farnsworth Div., IT&T
Tonotron	Available in 3-in. and 5-in.; 10- and 20-in. tubes under development.	Writing speed is 300,000 in. per sec (large sizes are 150,000 and 25,000 in. per sec).			Hughes Aircraft Co.
Memotron	Available in 5-in. tube.	Writing speed is 200,000 in. per sec. Writing speed of 1,000,000 in. per sec possible with special circuitry.	Persistence may last for days.	Cannot display halftones. Image presented must be intentionally erased. Erasure time is from 50 to 200 millisec.	Hughes Aircraft Co.
Dumont K1878	Available in 10-in. tube. Halftones can be reproduced with six levels of output brightness. Resolution is 50 lines per in. minimum.	Writing speed is a minimum of 20,000 in. per sec at maximum beam current.	Minimum storage of 3 min; erase time is 200 to 500 millisec.		Dumont Laboratories

tertainment television but may find considerable use in industry.

SCAN CONVERSION TUBES

Electronic information produced in a form which is not suitable for display can be converted to a form that is. One way to do this is the scan conversion tube. An application of this technique is the conversion of radar blips to a TV signal viewed on a television screen. Since a scan conversion tube provides storage, information can be put into the tube at one rate and withdrawn at another. In air traffic control the device permits the retention of aircraft location, so a dotted trajectory appears.

TYPE OF DISPLAY	KEY FEATURES	APPLICATIONS	ADVANTAGES	LIMITATIONS	SUPPLIER
SCAN CONVERSION TUBES	Nonviewing CRT into which video information can be stored at one rate and by one scanning method and from which the stored video can be extracted at a different rate and by a different scanning method. Raw radar data, for example can be inserted, stored, and subsequently displayed on a standard CRT at rates that circumvent the undesirable brightness and persistence characteristics of long persistence phosphors. The resulting display can be flicker-free, bright, and viewed under higher light levels than a standard radar display.				
Intec Video Transformation Tube TMA-403X	Double ended tube with magnetic deflection and electrostatic focusing on the write gun and electrostatic focusing and deflection on the read gun. Costs about $2,600. (See Figure 4.)	Resolution of 1,000 TV lines is claimed. Storage is adjustable from 0.1 sec to 20 min plus. It is possible to read the output signal on the order of 150 to 20,000 scans before erasure of the written information. The signal-to-noise ratio is 30 to 1.	Does not require RF modulation to sort the write and read signal. The tube is capable of halftone rendition. The tube shows 8 to 10 steps of gray in written information.		Intercontinental Electronics Corp.
Graphechon	Double ended, nonviewing, electrostatic charge storage tube. Costs about $1,100.	Used with scan conversion equipment, writing and reading can be conducted at the same time.	Can supply as many as 6,000 copies of stored information with a signal-to-noise ratio of 10 to 1.	Can produce only crude halftones. Requires some method of separating reading and writing signals usually RF modulation of time-sharing.	Radio Corp. of America
Radechon	Single ended, nonviewing barrier-grid charge storage tube. (See Figure 5.)	Can store information received in analog or digital form.	Storage time is controllable from microsec to minutes. Information can be read out a number of times.	Must be time shared for reading and writing.	Radio Corp. of America (Similar tube made by Farnsworth Div., IT&T).
Day Tube	Double ended storage tube. Uses three guns, electrostatic write and erase guns, and a magnetic read gun.	Scan conversion.	Storage time is several minutes.	Is still developmental.	General Electric Co.
Recording storage tube	Nonviewing device.	For scan conversion, indefinite image storage, slowed down video. Resolution is about 400 lines at 50 percent modulation level.	Signal can be stored for hours. Single image can be read out 20,000 times.	Time must be shared among four modes.	Raytheon
COLOR TUBES	Can be programmed to display different variations at the same time. Major differences between tubes below stem from their means of obtaining color stimulating different colors with separate guns or masking the phosphors.				
Chromatron	Two- and three-color tubes available. Phosphors are laid down in thin parallel strips of alternating colors. Two sets of grids direct electrons to the proper color. (See Figure 6.)	Color TV.	Brighter and more efficient than shadow mask color tube (below). No convergence or misregistration problems. Not affected by the earth's magnetic field. Uses essentially same deflection voltages as standard CRT's.	Requires elaborate power supply.	Litton Industries
Shadow mask tube	Uses three guns spaced 120 deg apart and view plate on which are deposited three phosphor dots of different colors (red, green, and blue) in a triangle. Shadow masks are placed between gun and dots so that each gun can hit only one color dot.	Color TV.		Sensitive to slight variations in the earth's magnetic field. Protection must be provided against X-radiation. Brightness is limited. Color purity is hard to obtain.	Radio Corp. of America
Color Storage Tube	Combines features of Tonotron with shadow mask tube.	Can write at speeds up to 300,000 in. per sec.	Capable of halftone presentation. Resolution is 30 to 35 lines per in.	Display area limited (doubtful if 20-in. tube can be built). Still in development stage.	Hughes Aircraft Co.
Prismachrome (Geer Tube)	Three colored phosphors are geometrically oriented on faces of minute ridges so that each gun illuminates only the desired phosphor.		Extremely rugged, cannot lose its registration alignment due to shock or vibration. High level of brightness is obtainable.	Tube is bulky for its screen size.	Hoffman Electronics Corp.
Penetron	Color CRT with thin color phosphors deposited in layers on the tube face. The tube has one electron gun; color selection is achieved by varying the accelerating potentials. Difference for successive layers is on the order of 3 to 4 kv.	May be able to pass from one primary color through all the intermediate hues to the next primary color by appropriately adjusting the accelerating voltage.	Simpler and more rugged than shadow mask tube or Chromatron.	Only two color tubes have been built. Still in development stage.	General Electric Co.

One type of tube, the Recording Storage Tube, is designed for indefinite storage of information—up to hours. Information can be read out as many as 30,000 times without deterioration.

SPECIAL TUBES

Some of the most interesting developments in display have occurred in the introduction of radically different cathode ray tubes, of which the Aiken tube, or flat cathode ray tube, appears among the most promising. In addition to reducing the volume of the display tube, the flat cathode ray tube is three times as bright as a conventional CRT, and has 20 times the focusing power. Further developments

TYPE OF DISPLAY	KEY FEATURES	APPLICATIONS	ADVANTAGES	LIMITATIONS	SUPPLIER
Apple Tube	Color TV system using a beam indexing tube. Three primary color phosphors are deposited in narrow vertical strips on the tube face with an additional strip used for locating the writing beam. An electron gun generates two beams, one for writing and one for developing an indexing signal. As the two beams scan horizontally, the indexing beam generates a signal which synchronizes the intensification of the writing beam with the dot-sequential type of color signals.	Compatible color TV system.	Said to be more efficient than shadow tube and has no convergence problem because it does not use masks or grids.	Requires many circuit adjustments.	Philco Corp.
SPECIAL TUBES	Radically different developments using cathode ray tube techniques that do not fit into any of the above groups. Advantages include brighter, sharper focusing in smaller space; high resolution; sharp display.				
Skiatron	A dark trace tube; therefore coating absorbs light when bombarded with electrons.	Available with a refractive optical projection system that can throw a 10-ft diameter picture. Writing speed is sufficient for producing raw radar data. Resolution of projected display is 1,100 lines.	Projected displays are clear and sharp. Although ambient lighting can deteriorate projected display, local illumination for reading and writing will not affect the display if rays are prevented from striking the screen.	Requires time to build up to full contrast and time to decay after excitation is removed. Tube may be erased in 2 sec, but additional 5 sec must elapse before re-writing can take place. To date limited to black trace on a bright background.	Skiatron Electronics and Television Corp.
Aiken Tube	Flat cathode ray tube. (See Figure 7.)	Linearity accuracy is 5 percent. Resolution is as high as 400 lines per in. Modifications under development: a) Two-color Aiken tube — glass plate with different colored phosphors is inserted between face plate and back plate of a standard Aiken tube. Uses a separate electron gun for each color. b) Three-dimensional Aiken tube. Cube-shaped tube contains horizontal glass layers, each coated with a transparent phosphor. Each layer has an electronic gun. No goggles or viewing equipment required but third dimension presentation is discrete rather than continuous. c) Flat polar-coordinate CRT. d) Charactron flat tube — normal electron gun is replaced by Charactron components.	Three times the brightness of a conventional CRT, and 20 times the focusing power. 21-in. tube requires only 20 percent of power needed by conventional CRT. Potentially can be built in large sizes, up to 3 by 5 ft.	Delivery of 20-in. tube is 6 months. Large tubes have not actually been built.	Kaiser Aircraft and Electronics Corp.
Light Valve Tube	Scanning electron beam deposits charges on a special semiconductor screen which changes from opaque to transparent in accordance with pattern of stored charges. A lamp behind the screen shines through the pattern projecting it like the light of a slide. (See Figure 8.)		Bright display because of separation of projection light source and pattern generating functions.	Requires an additional year of development work for production.	Resdel Engineering Corp.
Large Cathode Ray Tube (30-in.)	Will operate with 30,000 volts accelerating voltage, magnetic deflection	Tube has a curved face but is equipped with a plotting overlay to reduce parallax. Being built as a plan position indicator display.	Large display tube. Potentially high resolution, up to 1,000 lines.	High cost: $30,000. High voltage is hazard for operator. Brightness cannot compare to optical projection systems.	Polaroid Electronics Corp.* Du Mont Labs.
Moving Target Indicator INTEC TCM-13X	Barrier-grid storage tube. A high definition triode gun with simultaneous read and write. Electrostatic focus and deflection. 15 shades of gray. Resolution of 400 TV lines is derived as measured by orthogonal write and read technique and with a 50 percent output signal modulation.	In moving target indicator techniques the tube provides an elimination ratio of 33.	Speed velocity of 0.6 mm per microsec. Signals can be added and integrated.		Intercontinental Electronics Corp.
INTEC TCM-154	Barrier-grid storage tube. A high definition triode gun with electrostatic focus and deflection and astigmatism correction lens. Definition at 30 percent modulated output signal, the tube has about 700 TV lines.	Originally developed for electron switching in telephone circuits.	Erasure with television or similar-type raster; signals are stored and then read at a later time		Intercontinental Electronics Corp.

include a two-color tube, a three-dimensional display tube, a polar coordinate display, and a character generating flat tube.

Dark trace tubes have been built for projection systems giving clear and sharp images. Other special developments are a light valve tube which employs a variable opacity storage screen, large (30-in.) cathode ray tubes. It is expected that this will be available in 1961.

REFERENCE:

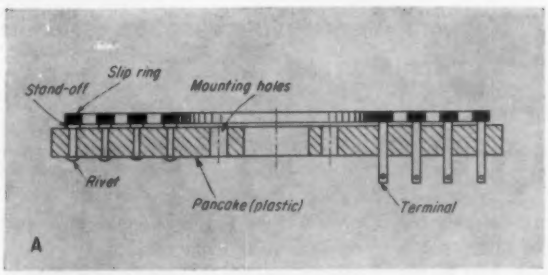
Techniques of Dynamic Display by Richard A. Barker, Stavid Engineering, Inc, Plainfield, New Jersey. Published in Control Engineering, February 1960, p. 100.

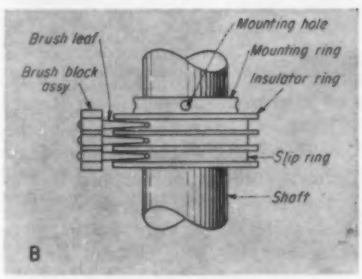
From: Company bulletin

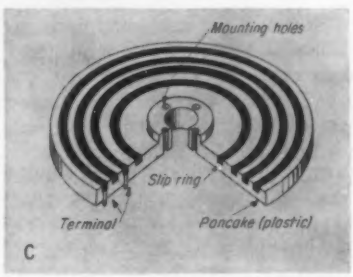
fundamentals of . . . SLIP-RING ASSEMBLIES

Types, construction hints, operation and limitations of general purpose rings.

General purpose slip ring assemblies are those used in relay, lighting and power supply circuits. These circuits are characterized by lack of sensitivity to external electrical influence induced by electrostatic or electromagnetic fields from other circuits. Another usual characteristic of these assemblies is their limited power handling requirements. For higher current and power requirements, the rings are usually classified as power rings.







SLIP-RING TYPES are: Drum type, fabricated or electroformed (A); Pan type, fabricated (B), and pan type, electroformed (C).

TYPES OF RINGS

Design techniques have been developed for small size and light weight. These are drum type, pan type, and electroformed assemblies.

The drum type are brushed on the surface bounded by the outside diameter. Another drum type ring is brushed on the flat surface. In this instance the brushes project between the ring surfaces.

Pan type construction consists of a concentric, nested set of rings on one plane.

CONSTRUCTION

It is relatively easy to make electroformed rings of the first mentioned drum type and the pan type, and they perform well as general purpose rings. However, choice of materials is limited.

The fabricated type construction will be superior and will surpass all the usual requirements of general purpose rings over the electroformed construction for universal applications.

Fabricated ring stacks are metal rings separated by plastic laminate insulators. The plastic laminate should be treated with an insulating varnish to seal the machined edges against the entrance of moisture. The rings may be continuous and machined from plate stock or stamped from sheet. The standard hardness for the rings is 125 BHN minimum.

Brush contact materials for slip rings are usually sintered silver-graphite; the silver provides the low contact and brush resistance, and the graphite provides lubrication for long wear.

OPERATION

As the brush moves with respect to the ring, and with current flowing from brush to ring or vice versa, there are variations in current flow resulting from the imperfect contact between the moving elements of the circuit. Even for general purpose slip-ring applications, this current variation is kept to a minimum by proper selection of compatible materials. The resistance variation seldom exceeds 0.005 ohms for double contacts on a ring. This is equivalent to about 1 ft. of 16 AWG copper wire.

LIMITATIONS

General purpose rings are usually limited to slow rotating speeds, not more than 1,000 rpm or less than 1,000 ft/min. If this speed is exceeded, the assembly is no longer considered a general purpose ring assembly, because special brush materials or even air cooling may become necessary.

Additional considerations for this type slip ring assembly come under the other type assemblies.

REFERENCE:

Fundamental Description of General Purpose Slip Ring Assemblies. Published by Engelhard Industries, Inc, D. E. Makepeace Div, Attleboro, Massachusetts.

From: ASTE Paper

for inspection and decision making . . .

ELECTRONIC GAGING

How sensing elements, gage circuits, sum computers and difference computers can increase speed, sensitivity and accuracy of inspection.

DAVID R. HOUCK
Application Engineer
Industrial and Machine-tool Operations
Radio Corporation of America

The increasing demand in industry for tolerances is requiring faster, more reliable, and versatile inspection methods. These requirements are stimulating electronic inspection and decision-making methods. While it may not be necessary for the design engineer to understand the electronic theory involved, it is increasingly necessary that he knows the general capabilities of electronic inspection methods.

The first step in acquiring a working knowledge of electronic inspection and decision-making methods is to understand the nomenclature and functions of the basic elements employed. While there are several widely used electronic systems for obtaining dimensional measurements, the functions of the elements used are, for all practical purposes, the same.

BASIC COMPONENTS

The Sensing Element. This element is often referred to as a displacement transducer. One of the most commonly used types is the variable capacitor, Fig. 1. The sensing element can be considered a gaging stylus which is displaced by the dimensional change of part size or by the amount of motion of the contacted surface.

Gage Circuit. The function of this element is to transform the electrical change caused by the displacement of the sensing element into a usable signal for deflecting the pointer of a meter or for operating electronic limit switches. The chief advantage of a system that has a variable capacitor as its sensing element is that its gage circuit has an extremely high output voltage which can be used directly without intermediate multi-stage amplifiers. A standard recorder or a meter can be connected to the gage unit to give a visual indication of size.

However, other elements must be used to make automatic decisions from electrical information supplied by the sensing element and gage circuit. The most preferred element is the electronic switch. This element can be considered a limit switch which, rather than reacting to mechanical motion, is energized by an electrical signal of a specific magnitude from a gage circuit. Thyratron tubes for example are set to fire at a preset voltage value and energize a relay. This in turn can operate a light, bell, or an electrically actuated sorting mechanism. The switch is connected to the output of the gage circuit and will fire when the output voltage of the gage reaches the preset voltage value.

Since the output voltage of the gage is the indication of part size, the switch can be set to fire at a predetermined part size. To sort parts into undersize, acceptable tolerance size, and oversize categories, use two electronic switches—the first switch set to energize its relay at the low tolerance limit, and the second switch set for the high limit. A part which did not cause the gage to operate either switch would, of course, be undersize. If the first switch is actuated but not the second switch, the part is within the acceptable tolerance range. If both the first and second switches are actuated, the part is oversize. By using a chain of switches, parts can be sorted into any number of categories for selective fit to assemblies.

Other extremely important elements in the decision-making phase of an electronic inspection system are the computers:

Sum Computer. This element is used for adding the output signals of two gage circuits.

Difference Computer. This unit is used for subtracting the output signals of and a sum computer.

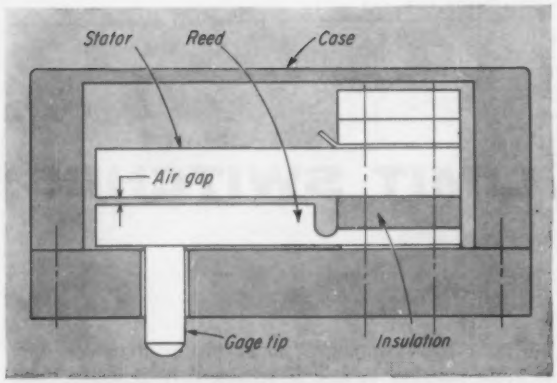
The above elements can be combined in a variety of ways to determine almost any measurable dimension and even some physical properties.

WORKING EXAMPLES

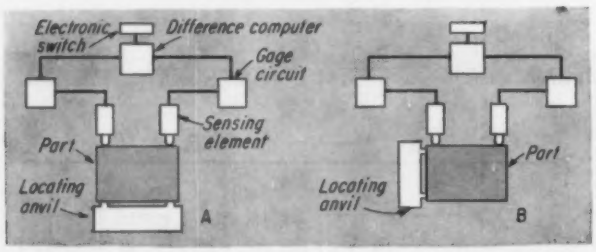
To measure overall length of one cross member of a universal joint cross, Fig. 2, and determine the length of each segment with respect to the centerline of the other cross member, the three desired measurements can be found by the use of two gage circuits and a sum computer.

A gage unit will measure the length of each of the two segments, the sum computer will add the two measurements to give the over-all length.

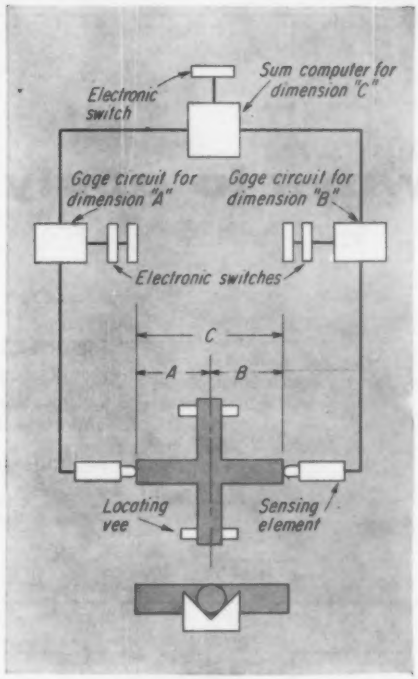
To measure width and parallelism of a rectangular part, Fig. 3, measure the width at each end with two gage



1.—VARIABLE-CAPACITOR SENSING-ELEMENT is low-cost unit that can be incorporated into efficient inspection setups.



3.—WIDTH AND PARALLELISM of a rectangular part (A) can be measured by same sensing elements when position of locating anvil can be changed. Squareness is measured at "A".



2.—OVERALL LENGTH of a universal-joint cross. Three lengths are determined here by only two sensing elements.

circuits, and determine parallelism by means of a difference computer. If necessary, the direction of any out-of-parallel condition can be found by electrically determining if the difference of the two readings is plus or minus.

Surface hardness is measured by the penetration of an indentor under a specified load. By using a sensing element to measure the travel of the penetrator, a gage circuit, two electronic switches, and appropriate sorting mechanism, parts can be automatically segregated into categories of too-soft, acceptable and too-hard.

Weighing can be accomplished by measuring the deflection of a beam.

Spring force can be determined in the same manner.

Out-of-roundness and concentricity can be measured by gage circuits modified to react to a change of reading only—actual diameter size does not influence the final answer.

MAJOR ADVANTAGES

While any of the above inspection problems can, in many cases, be solved with pneumatic or electrical gaging techniques, electronic methods offer the following major advantages.

1. **Higher Speed.** Because the time required for an electronic gaging system to resolve an answer is, for all practical purposes, negligible, the inspection rate of an electronic inspection and sorting system is limited only by the time required for the mechanical motions involved in getting the parts to and from the gaging fixture. Some typical inspection and sorting rates of automatic machines using electronics are:

Diameter inspection of bearing rollers—15,000 per hour.

Hardness inspection — 4,000 per hour.

Out-of-round inspection—3,000 per hour.

Weighing—6,000 per hour.

2. **Greater sensitivity and accuracy.** Under ideal laboratory conditions electronic gage circuits can indicate dimensional variations in size as small as 0.000002 in. When properly applied, electronic gaging and segregating methods can be used on automatic machines for accurately checking and sorting parts having dimensional tolerances as small as 0.000020 in.

Although present electronic inspection methods are today enabling us to solve measurement problems which were thought unsolvable only a few years ago and we speak of millionths of an inch rather than thousandths, there are many future developments in methods that will far surpass those of today. Electronic inspection methods for process control will also greatly increase. The engineer must, therefore, be alert to new developments, and maintain a working knowledge of electronic-inspection fundamentals and decision-making methods if he is to take full advantage of their broad capabilities. It should never be forgotten that one most important bonus can be reduced cost of product.

REFERENCE:

Parts Inspection and Decision Making by Electronics by David R. Houck, Application Engineer, Industrial and Machine-tool Operations, Radio Corporation of America. ASTE Technical Paper no. 231.

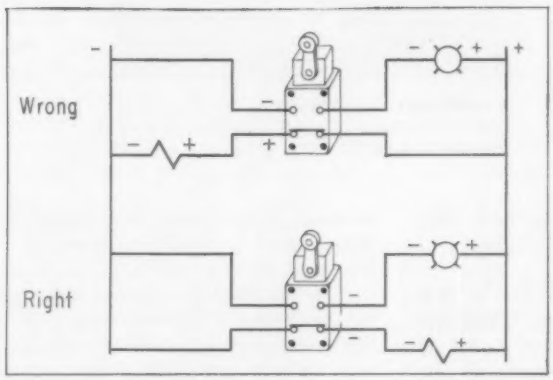
From: NEMA Bulletin

16 ways to apply . . . LIMIT SWITCHES

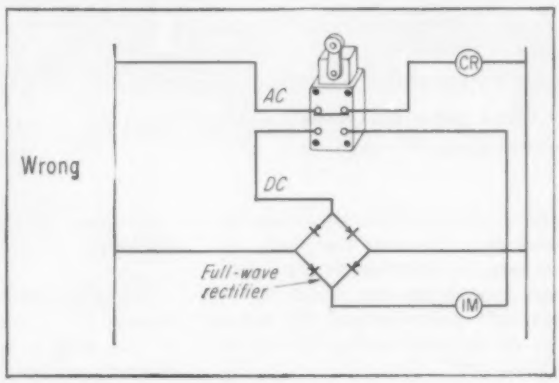
Industrial limit switches are a basic component in all phases of process and manufacturing control. Limit switches are now so reliable that, generally, they can be mounted and forgotten. For trouble-free operation, however, it is important that they are correctly applied. The following instructions show how.

REFERENCE:

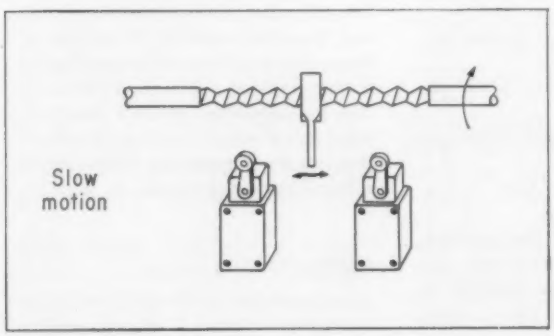
Precision Snap-acting Switches, Standards Publication No. IC 3-1959. Published by National Electrical Manufacturers Association, 155 E 44 St, New York, New York.



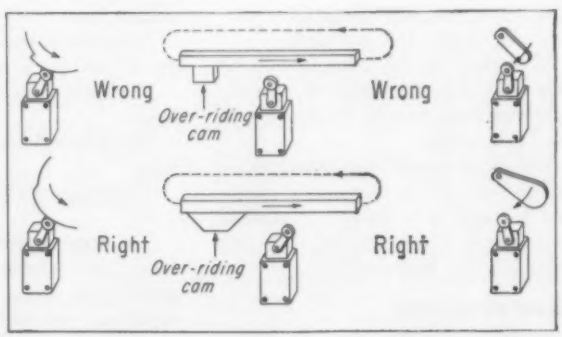
1. . OPPOSITE POLARITIES should not be connected to the contacts of one limit switch unless the limit switch is specifically designed for such service.



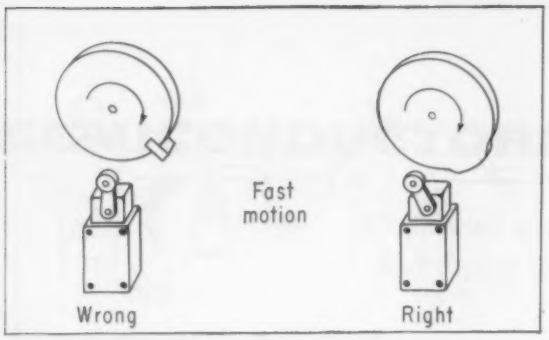
2. . POWER from different sources should not be connected to the contacts of one limit switch unless specifically designed for such service.



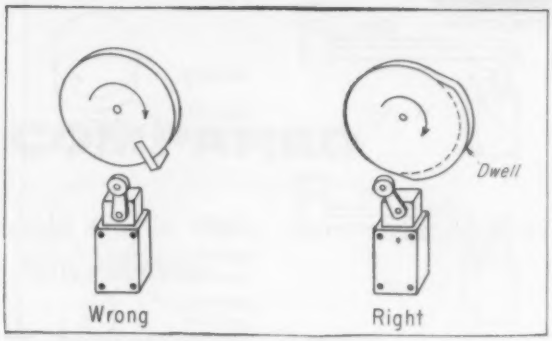
3. . SNAP-ACTING limit switches should be used when they are actuated by relatively slow motions.



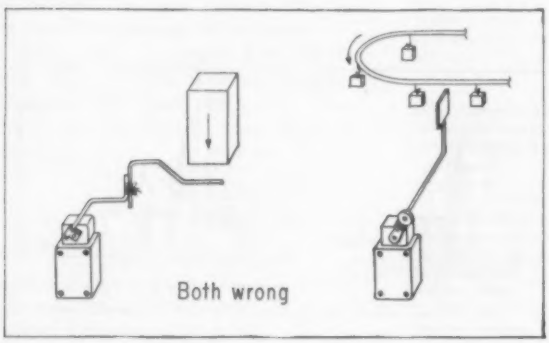
4. . CAM or dog arrangements should be such that the actuator is not suddenly released to snap back freely.



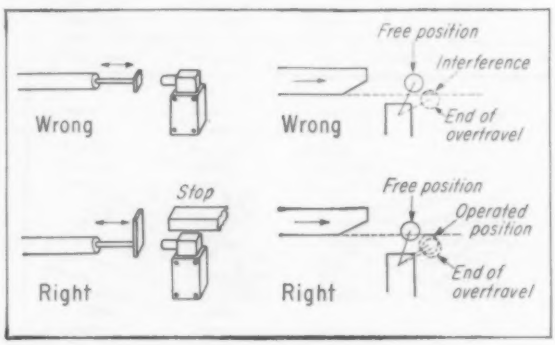
5. . **SEVERE IMPACT** can damage switch. Make sure cam is designed to avoid giving actuator a severe impact.



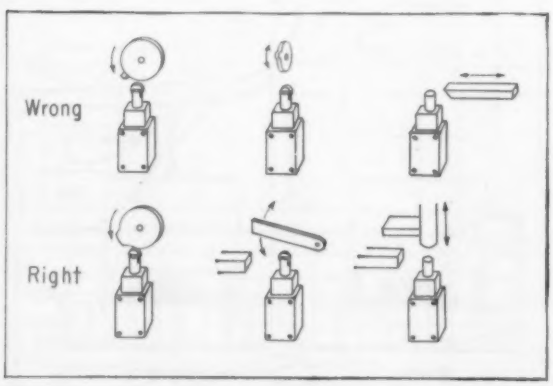
6. . **HOLD** contact long enough to operate relays, valves, etc., where relatively fast motions are involved.



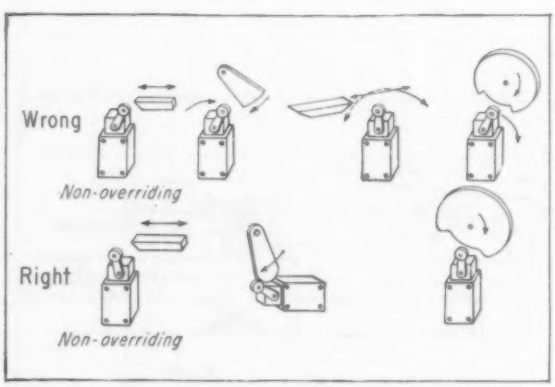
7. . **SUPPLEMENTARY ACTUATORS** should not be used unless the limit switches are specifically designed for them. If, however, in emergency, such supplementary actuators must be used, make sure that whip effect will not cause trouble.



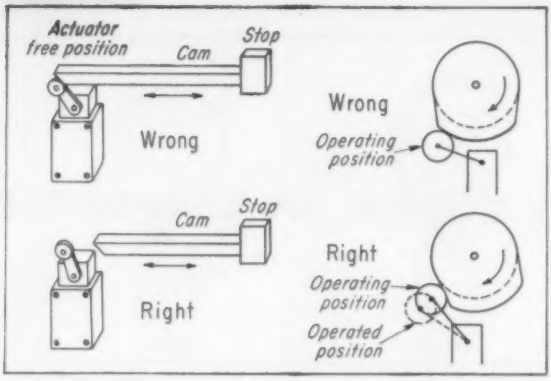
8. . **OPERATING MECHANISMS** for limit switches should be so designed that, under any operating or emergency conditions, the limit switch is not operated beyond its over-travel limit position. A limit switch should not be used as a mechanical stop.



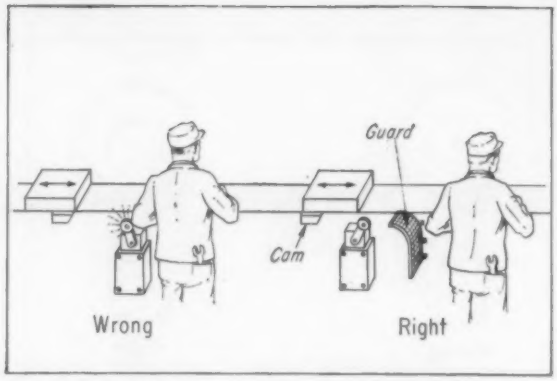
9. . **FOR PUSHROD ACTUATORS,** the actuating force should be applied as nearly as possible in line with the pushrod axis. This will then prevent any undue resultant forces from causing excessive wear.



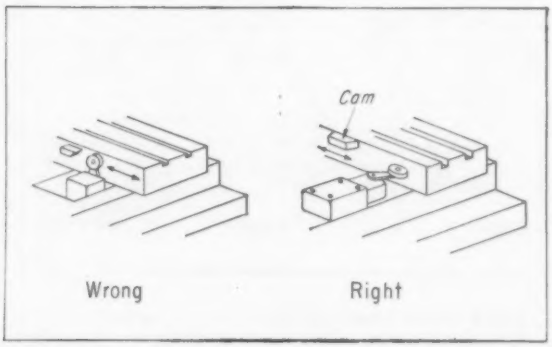
10. . **FOR LEVER ACTUATORS,** the actuating force should be applied as nearly perpendicular to the lever as practical and perpendicular to the shaft axis about which the lever rotates.



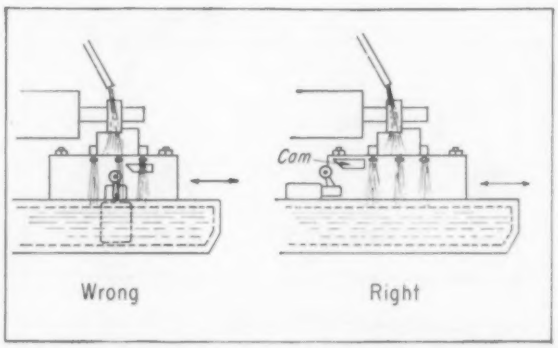
11. . **ACTUATOR** must be allowed to move far enough for positive operation of the contacts.



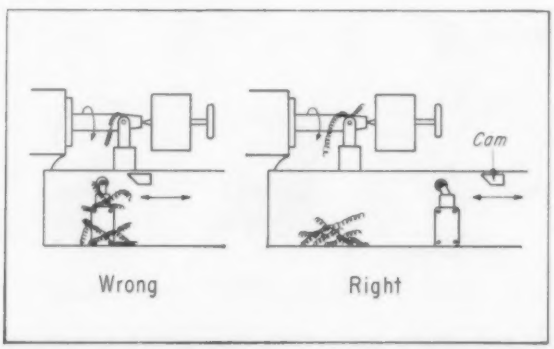
12. . **MOUNT LIMIT** switches in locations that will prevent false operation by normal movements of operator or machine components.



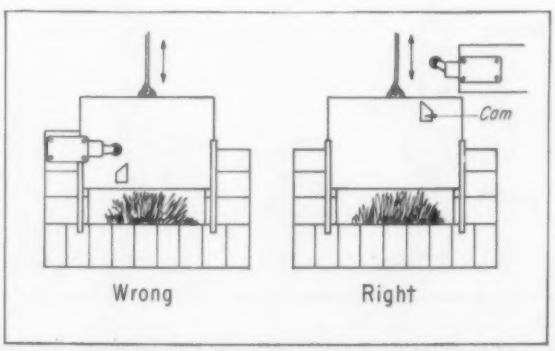
13. . **RIGID MOUNTING** in readily accessible locations, with suitable clearances to permit easy service is important. Cover plates should face the maintenance access point.



14. . **DON'T SUBMERGE** or splash switches with oils, coolants, or other liquids unless they are designed for such service.



15. . **PLACE SWITCHES** in locations where machining chips do not accumulate under normal operating conditions.



16. . **TEMPERATURE** or atmospheric conditions must not be beyond those for which the limit switch has been designed.

From: Power

SEMICONDUCTORS COMPARED

Tabulated and charted data on silicon, germanium, selenium and copper oxide semiconductors.

Dc-powered products are on the increase. Since most of today's electric power is generated in 60-cycle form, dc loads must be fed through converters or rectifiers. Semiconductors, especially silicon, are continually bidding successfully for ever-larger power-conversion jobs throughout industry.

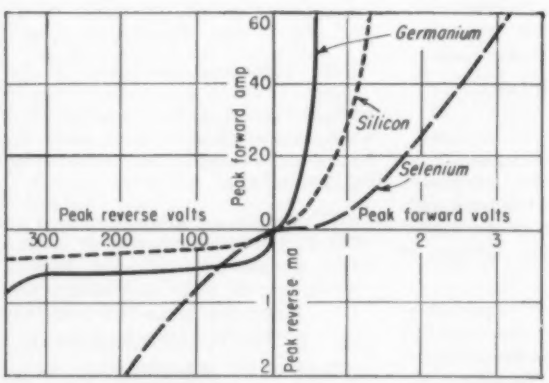
The table presented here shows how different types of semiconductors compare; the charts plot various electrical characteristics of these types of rectifiers.

REFERENCE:

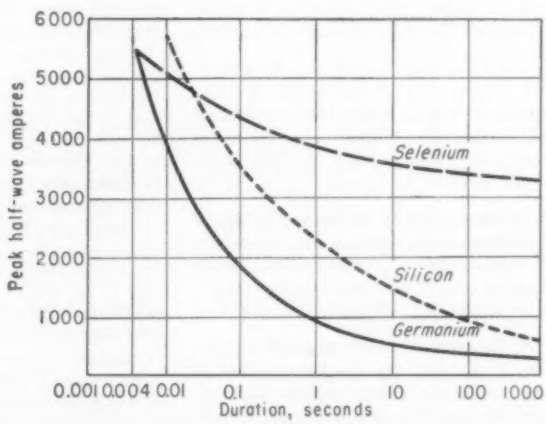
Electrical Conversion by Norman Peach, Associate Editor, Power. A Power Special Report, December 1959, p. 67.

How Semiconductors Compare

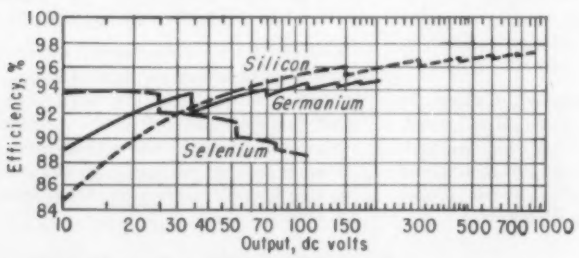
Characteristic	Silicon	Germanium	Selenium	Copper oxide
Size	Very small	Very small	Large	Large
Weight	Very light	Very light	Light	Heavy
Cooling	Natural or forced	Natural or forced	Natural or forced	Natural or forced
Life	Very long	Very long	60,000–100,000 hr (convention-cooled ratings)	Long-proven
Aging (forward resistance)	None	None	Increases	Stabilizes
Forward loss at same current density	Good	Excellent (lowest)	Fair (highest)	Good
Leakage (reverse current)	Excellent	Excellent	Good	Fair
Ability to heal	None	None	Excellent	Good
Unforming	None	None	Appreciable (low-temp process)	None
Series operation of cells	Good	Good	Excellent	Excellent
Parallel operation of cells	Good	Good	Excellent	Excellent
Cell-operating temperature limit	250 C	85 C	85 C	75 C
Thermal capacity	Poor	Poor to good	Fair	Best
Humidity effects	Hermetically sealed	Hermetically sealed	Negligible	Negligible
Frequency response	Good	Good	Poor	Fair



1. . FORWARD-REVERSE characteristics of typical semiconductor cells indicate suitability of each to different voltage-current ratios.



2. . OVERLOAD capacity of typical individual cells shows susceptibility of silicon, germanium. Cells are derated for particular jobs.



3. . EFFICIENCY of germanium and silicon is highest toward upper voltage range while selenium falls off; selenium is not usually recommended for high voltage.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(I-1) Thermocouple Wire—Brochure, 4 pp. Describes flexible, metal sheathed, ceramic insulated wire for up to 3000F. Aero Research Instrument Co, 350 N Aberdeen St, Chicago 6.

(I-2) Terminal Blocks—Catalog, 12 pp. Shows terminal blocks of unit or interlocking construction, solderless connectors and terminals, cable and conduit fittings. Buchanan Electrical Products Corp, 426 US 22, Hillside, NJ.

(I-3) Snap-action Switches—Catalog, 4 pp. Describes a basic switch modified for various methods of actuation. Suitable for appliances. Cherry Electrical Products Corp, 1650 Deerfield Rd, Highland Park, Ill.

(I-4) Pilot Lights—Handbook, 256 pp. Discusses how to select the proper pilot light to accomodate the required lamp. Dialight Corp, 60 Stewart Ave, Brooklyn 37, NY.

(I-5) Printed Circuit Laminate—Brochure, 16 pp. Explains different methods of producing copper clad, plastic laminate printed circuits. Lists properties of products. Formica Corp, Subs of American Cyanamid Co, 4516 Spring Grove Ave, Cincinnati 32.

(I-6) Timers—Five bulletins, 10 pp. Describes ac and dc timing motors; interval and cycles timers. Haydon Div of General Time Corp, 235 E Elm St, Torrington, Conn.

(I-7) Rotary Selector Switches—Catalog, 20 pp. Provides specifications and dimensions of standard rotary selector switches of the totally enclosed environmental proof type. Janco Corp, 3111 Winona, Burbank, Cal.

(I-8) Hermetic Terminal Assemblies—Catalog, 21 pp. Provides complete coverage of electrical characteristics, outline drawings, parts breakdowns, dimensions and mounting information. Includes high voltage and high current types. Lundey Associates Inc, 694 Main St, Waltham, Mass.

(I-9) Enclosed Airborne Switches—Catalog, 16 pp. Provides data on environment-proof, high temperature, hermetically sealed, metal enclosed switches for exposed airborne applications. Micro Switch, Div of Minneapolis-Honeywell Regulator Co, Chicago at Spring Sts, Freeport, Ill.

(I-10) Plastic Enclosed Switches—Catalog, 32 pp. Presents dimensions, electrical and operational characteristics of a wide variety of industrial and commercial switches. Micro Switch, Div of Minneapolis-Honeywell Regulator Co, Chicago at Spring Sts, Freeport, Ill.

(I-11) Small Switches—Catalog, 20 pp. Describes miniature, subminiature push-button switches and auxiliary actuators including arrangements for toggle or rotary gang operation. Micro Switch, Div of Minneapolis-Honeywell Regulator Co, Chicago at Spring Sts, Freeport, Ill.

(I-12) Enclosed Industrial Switches—Catalog, 20 pp. Describes metal enclosed, snap-action, high capacity switches for industrial environments. Micro Switch, Div of Minneapolis-Honeywell Regulator Co, Chicago at Spring Sts, Freeport, Ill.

(I-13) Airborne Switches—Catalog, 32 pp. Describes plastic and metal enclosed snap switches suitable for airborne equipment. Micro Switch, Div of Minneapolis-Honeywell Regulators Co, Chicago at Spring Sts, Freeport, Ill.

(I-14) Lighted Indicator Switches—Catalog, 20 pp. Shows lighted indicators, push-button switches and combinations for modular installation. Micro Switch, Div of Minneapolis Regulator Co, Chicago at Spring Sts, Freeport, Ill.

(I-15) Mercury Switches—Catalog, 12 pp. Provides data on ac and dc types in small size, general use, protected and low angle designs. Micro Switch, Div of Minneapolis-Honeywell Regulator Co, Chicago at Spring Sts, Freeport, Ill.

(I-16) Switches—Catalog, 24 pp. Shows representative industrial, commercial and electronics switches. Micro-Switch, Div of Minneapolis-Honeywell Regulator Co, Chicago at Spring Sts, Freeport, Ill.

(I-17) Insulating Tape—Bulletin, 4 pp. Provides specifications of silicone rubber self-adhering tape. Moxness Products, Inc, 1914 Indiana Ave, Racine, Wisc.

(I-18) Relays and Solenoids—Catalog, 28 pp. Gives dimensions, electrical and operating characteristics. Relays and solenoids designed as components for control and electronics equipment. Joseph Pollak Corp, 85 Freeport St, Boston 22.

(I-19) Aluminum Conduit—Brochure, 4 pp. Gives sizes, installation instructions and advantages of conduit and fittings. Reynolds Metals Co, Richmond 18, Va.

(I-20) Aluminum Strip Conductor—Bulletin, 12 pp. Explains how to design for anodized strip as transformer or magnetic coil windings. Reynolds Metals Co, Richmond 18, Va.

(I-21) Printed Circuit Laminate—Brochure, 6 pp. Presents specifications, manufacturing methods of plastic laminate clad with copper foil. Synthane Corp, River Rd, Oaks, Pa.

(I-22) Glass Sealing Alloy Wire—Data folder, 9 pp. Gives current capacity, coefficient of thermal expansion of copper cored wire for glass to metal sealing. Texas Instruments, Inc, Metals & Controls Div, 72 Forest St, Attleboro, Mass.

(I-23) Electrical Contacts—Data folder, 16 pp. Describes clad projection welding contact buttons, contact tape, parts and assemblies. Texas Instruments, Inc, Metals & Controls Div, 72 Forest St, Attleboro, Mass.

(I-24) Cartridge Heater—Brochure, 6 pp. Graph and explanation help in choosing right heater. Lengths vary from $\frac{3}{4}$ to 12 in. Maximum wattage is 4700. Watlow Electric Mfg Co, 1376 Ferguson Ave, St Louis.

(I-25) Electric Heaters—Catalog, 45 pp. Covers cartridge, strip, cylindrical immersion and tubular heaters. Includes list price, wattage charts, circuit diagrams and installation methods. Watlow Electric Mfg Co, 1376 Ferguson Ave, St Louis.

(I-26) Potentiometers—Catalog, 28 pp Illustrates potentiometers and trimmers in such varieties as linear, nonlinear, high temperature, miniature and smaller. Ace Electronics Associates, Inc, 99 Dover St, Somerville, Mass.

(I-27) Switches and Relays—Catalog, 4 pp. Gives operating characteristics of switches from machine tool size to subminiature. Relays have 10 to 20 amp ratings. Acro Div, Robertshaw-Fulton Controls Co, 2040 E Main St, Columbus, Ohio.

(I-28) Mercury Relays—Catalog, 8 pp. Presents operating principles, ratings, dimensions, selection factors. Includes time delay and quick acting types. The Adams & Westlake Co, 1025 N Michigan St, Elkhart, Ind.

(I-29) Porcelain—Bulletin, 4 pp. Discusses properties of porcelain that make it a good insulator and the uses to which porcelain may be put. Also outlines manufacturing facilities of company. The Akron Porcelain Co, 2792 Cory Ave, Akron 14, Ohio.

(I-30) Relays—Catalog, 42 pp. Shows dimensions, operating data, some circuits for miniature, subminiature, telephone, general purpose, power sensitive and special relays. Allied Control Co, Inc, 2 East End Ave, NYC 21.

(I-31) Switches and Terminals—Catalog, 24 pp. Shows dimensional drawings for single and multiple types for electrical appliances. Ark-Les Switch Corp, 51 Water St, Watertown, Mass.

(I-32) Contact Meter-relays—Catalog, 28 pp. Describes operation in controls systems. Includes dimensions, electrical characteristics, circuits. Assembly Products, Inc, 75 Wilson Mills Rd, Chesterland, Ohio.

(I-33) Donut Transformers—Bulletin, 4 pp. Lists dimensions and ratings of current transformers with ratios from 2:1 to 1000:1, burden ratings from 2.5 to 12.5 kv. Associated Research Inc, 3789 W Belmont Ave, Chicago 18.

(I-34) Capacitors—Catalog, 88 pp. Provides dimensions and specifications for the following types: electrolytic, metallized mylar, metallized paper, mylar, paper. Astron Corp, 255 Grant Ave, E Newark, NJ.

(I-35) Potentiometers—Bulletins, 8 pp. Presents drawings and specifications of miniature, subminature wire-wound, lead-screw trimmers. Atohm Electronics, 7648 San Fernando Rd, Sun Valley, Cal.

(I-36) Tube Shields—Catalog, 26 pp. Provides dimensions, specifications for clips, cradles, crystal and relay sockets, heat dissipating tube shields. Augat Bros, Inc, 33 Perry Ave, Attleboro, Mass.

(I-37) Electronics Clamps—Catalog, 68 pp. Provides dimensioned drawings of clamps for tubes, relays, capacitors, other components. Augat Bros, Inc., 33 Perry Ave, Attleboro, Mass.

(I-38) Relay Sockets—Catalog, 8 pp. Shows socket and clip assemblies for micro-miniature relays. Augat Bros, Inc, 33 Perry Ave, Attleboro, Mass.

(I-39) Meters—Catalog, 18 pp. Contains specifications and dimensions for ac and dc voltmeters, frequency meters, ac meters and monitoring packages. Helipot Div, Beckman Instruments, Inc, 2500 Fullerton Rd, Fullerton, Cal.

(I-40) Transistorized Amplifier—Bulletin, 6 pp. Provides specifications, block diagram and examples of uses in data processing equipment. Beckman, Systems Div, 325 N Muller Ave, Anaheim, Cal.

(I-41) Potentiometers—Catalog, 18 pp. Provides specifications, dimensioned drawings of single-turn, multi-turn, trimming types and others. Helipot Div, Beckman Instruments, Inc, 2500 Fullerton Rd, Fullerton, Cal.

(I-42) Electron Tubes—Catalog, 60 pp. Provides electrical and mechanical characteristics and drawings of microwave, receiving and gas tubes. Bendix Aviation Corp, Red Bank Div, Rte 35, Eatontown, NJ.

(I-43) Semiconductor Products—Catalog, 32 pp. Provides technical data sheets, dimensions and curves for germanium power transistors and silicon power rectifiers. Bendix Semiconductor Products, Westwood Ave, Long Branch, NJ.

(I-44) Instruments—Bulletin, 12 pp. Describes common electrical test meters plus cable fault locating equipment and other motor and power test instruments. Also tachometers, frequency meters. James G Biddle Co, 1316 Arch St, Philadelphia 7.

(I-45 Potentiometers—Brochure, 4 pp. Provides specifications table for miniature wirewound and carbon leadscrew potentiometers. Bourns, Inc, Trimpot Div, 6135 Magnolia Ave, Riverside, Cal.

(I-46) Rectifiers—Brochure, 4 pp. Provides electrical characteristics of selenium, copper oxide and silicon rectifiers. Bradley Semiconductor Corp, 275 Welton St, New Haven, Conn.

(I-47) High Temperature Wire—Brochure, 4 pp. Provides performance data on wire made to withstand temperatures to 200C. William Brand-Rex Div, American Enka Corp, 31 Sudbury Rd, Concord, Mass.

(I-48) Miniature Coaxial Cables—Brochure, 4 pp. Gives data table covering teflon insulated cable with braided glass or plastic jackets conforming to commercial and military specifications. William Brand-Rex Div, American Enka Corp, 31 Sudbury Rd, Concord, Mass.

(I-49) Dry Batteries—Catalog, 6 pp. Gives size, weight, voltage of batteries for radio, electronics, industry, other applications. Burgess Battery Co, Division of Servel, Inc, Freeport, Ill.

(I-50) Insulation Tubing—Catalog, 22 pp. Contains properties and specifications for plastic and coated tubing, heat treated glass sleeving and identification markers. William Brand-Rex Div, American Enka Corp, 31 Sudbury Rd, Concord, Mass.

(I-51) Contact Strips and Rings—Bulletin, 6 pp. Gives dimensions and drawings of beryllium copper electron tube contact rings and high frequency equipment strips. H Braun Tool & Instrument Co, Inc, 140 Fifth Ave, Hawthorne, NJ.

(I-52) Miniature Lamp Bulbs—Catalog, 22 pp. Furnishes nomenclature and tables of characteristics. Chicago Miniature Lamp Works, 1500 N Ogden Ave, Chicago.

(I-53) Nickel-cadmium Batteries—Catalog, 4 pp. Provides capacity, voltage, other electrical and physical properties of sealed, rechargeable batteries. Burgess Battery Co, Div of Servel, Inc, Freeport, Ill.

(I-54) Connectors—Catalog, 49 pp. Describes electrical and electronic connectors with removable contacts. Includes plating data and a selection chart. Burndy Corp, Omaton Div, Richards Ave, Norwalk, Conn.

(I-55) Ceramic Parts—Bulletin, 2 pp. Describes ceramic components, ceramic to metal composites, metallized ceramics, glass to metal composites and special microwave attenuating materials. CFI Corp, Cottage Pl, Mineola, NY.

(I-56) Electronic Components—Catalog, 91 pp. Describes hardware, capacitors, coils, terminals, patch panels, memory frames, other similar parts. Cambridge Thermionic Corp, 445 Concord Ave, Cambridge, Mass.

(I-57) Connector Plugs—Catalog, 8 pp. Provides assembly instructions, dimensions for modular design plugs using crimped contacts. Cannon Electric Co, 3208 Humboldt St, Los Angeles 31.

(I-58) Switches—Catalog, 11 pp. Presents dimensions and specifications for a wide variety of switches rated up to 30 amps @ 250 v or 2 hp. Carling Electric Co, 505 New Park Ave, W Hartford 10, Conn.

(I-59) Rotary Power Supplies—Catalog 8 pp. Describes equipment such as dc to ac converters, frequency changers and others for operating electrical gear from nonstandard or mobile power sources. Carter Motor Co, 2773 W George St, Chicago 18.

(I-60) Electronic Components—Catalog, 44 pp. Describes capacitors, variable resistors, switches and packaged circuits. Centralab, The Electronics Div of Globe-Union, Inc, 900 E Keefe Ave, Milwaukee 1.

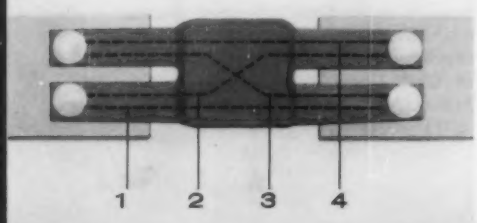
(I-61) Ceramic Parts—Brochure, 16 pp. Shows properties of materials, standard shapes, design considerations. Explains production methods. Centralab, The Electronics Div of Globe-Union, Inc, 900 Keefe Ave, Milwaukee 1.

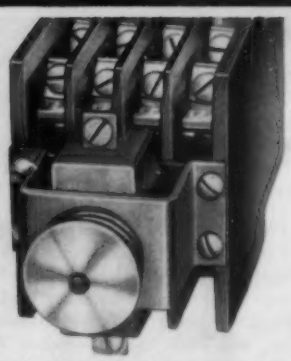
(I-62) Electronic Switches—Catalog, 36 pp. Contains dimensional drawings, specifications of standard and miniature phenolic and ceramic lever action spring return switches. Centralab, The Electronics Div of Globe-Union, Inc, 900 Keefe Ave, Milwaukee 1.

continued

Another Cutler-Hammer first! Up to 24 poles in an area less than the size of a dollar bill.

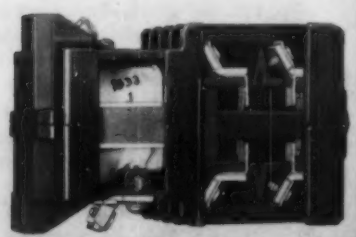
New contact reliability. Parallel bifurcated contacts, which allow four current paths instead of one, provide infinitely greater circuit reliability . . . liberally designed so any current path carries full relay rating.





At last! "Mechanical memory" latch as reliable as the relay itself! No adjustment ever needed. Add latch at any time.

New simplified design! Cutaway view shows basic simplicity. Coil vacuum impregnated to resist damage from humidity, vibration, electrical stress. Terminals can be screw or spade type.



Space savingest relay you've ever seen: New Cutler-Hammer "Compact 300"

Versatile 300 V. control relay is so reliable it's permanently sealed!

Here is the best answer yet to the need for an extremely reliable, small-size 300 V, 6 amp., industrial relay — the new "Compact 300" from Cutler-Hammer.

Every detail known that affects relay reliability has been improved in the "Compact 300." Bifurcated contacts which make possible *four* current paths rather than one, add millions of operations to the "Compact 300's" electrical reliability.

In fact, we're so confident of its electromechanical reliability, we permanently enclose the "Compact 300." And, if it should be damaged by a fault current, you throw it away and replace it with a new one. Its low price makes this an economical, practical maintenance procedure.

Now think of the space you can save with the "Compact 300." It controls up to eight circuits in panel space only 2″ wide by 2¾″ high. 2, 3, 4, 6 and 8 poles with any combination of N.O. or N.C. contacts are available, of course.

At any time, you can add "mechanical memory" latch with a life equal to the life of the relay. No adjustments are ever necessary. Contact your Cutler-Hammer distributor for details on the "Compact 300" or send for Pub. ED-L079-S206.

What's new at Cutler-Hammer? New, better products, like the 300 V. relay are coming steadily from our new, expanded plant facilities. We're ready now to help you take care of the great industrial growth of the future. If you are planning ahead and need electrical control assistance, contact the nearest Cutler-Hammer sales office.

WHAT'S NEW? ASK...

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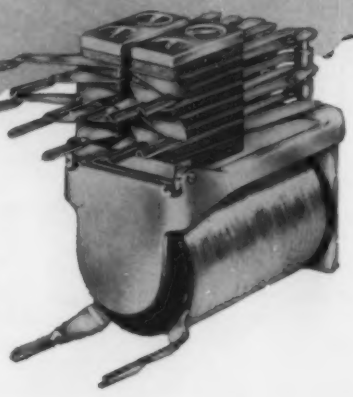
Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.

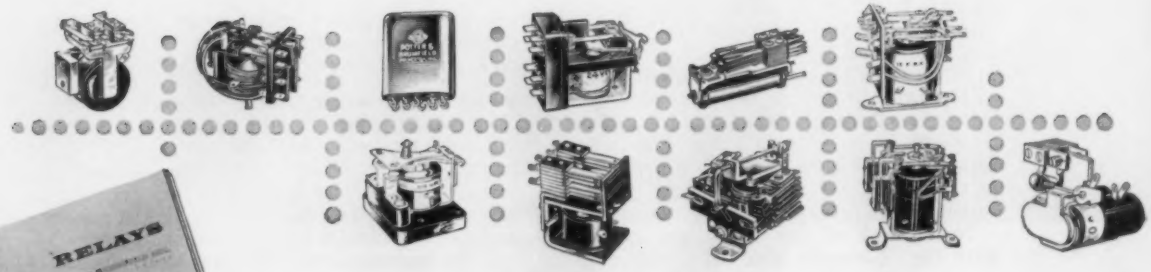
CIRCLE 449 ON READER SERVICE CARD

TO ALL RELAY USERS

PRODUCING SPECIAL RELAYS FOR SPECIFIC NEEDS IS A P&B FORTE- IN 26 YEARS WE HAVE DESIGNED MORE THAN 20,000 VARIATIONS OF 57 BASIC RELAY TYPES- CHANCES ARE, WE CAN SAVE YOU BOTH TIME AND MONEY=



Let us have your toughest relay problems. Remember, designing, engineering and manufacturing relays is our sole business. Shown here are just a few of the broad line of P&B quality relays . . . the relays preferred by most engineers.



FREE CATALOG upon request. Write today.

See Potter & Brumfield relays in SWEET'S PRODUCT DESIGN FILE.

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY - PRINCETON, INDIANA

450 CIRCLE 450 ON READER SERVICE CARD

CIRCLE 451 ON READER SERVICE CARD→

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HUDSON PRECISION-DRAWN CLOSURES

Precision Standard Tooling makes the Difference – The HUDSON line provides complete versatility for the designer/engineer. The industry's widest range of round, square and rectangular closures supplied with dozens of modifications to meet unusual applications. Standardized designs assure fast delivery and precision quality – every time! All finishes available on components of mu metal, nickel-silver, aluminum, brass, copper, stainless steel and steel. Call or write for quotations.

Available faster than *FAST!*

Ask for the HUDSON CATALOG — contains complete data on HUDSON Standard Closures including MIL types. Please make request on company letterhead.

Hudson Tool & Die Company · Inc
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Precision Metal Components for Electronics, Nucleonics, Avionics and Rocketry

Telephone: MArket 4-1802
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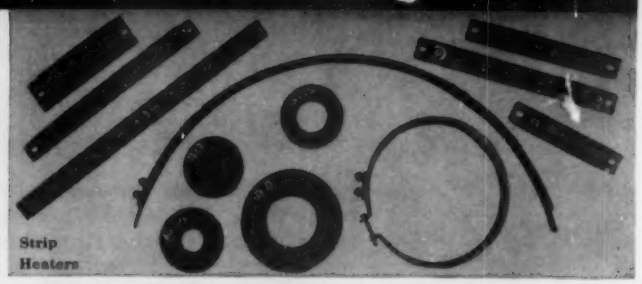
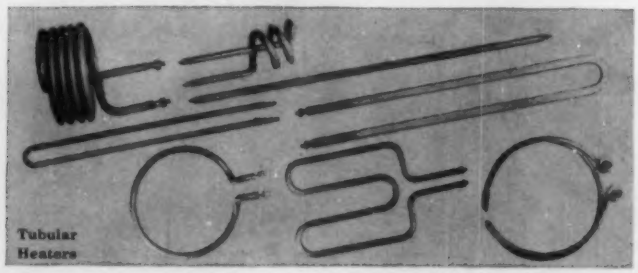
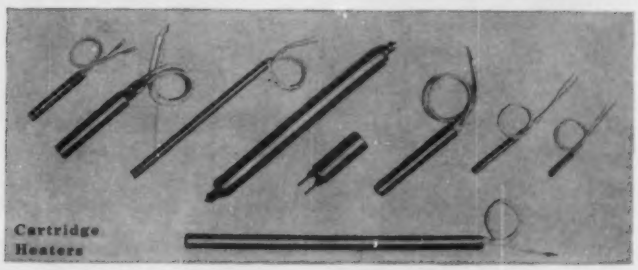
Call your CHROMALOX Man for the heating answers







These 3 basic CHROMALOX heaters provide answers to just about any heating problem

Strip Heaters . . . that quickly and easily bolt or clamp to platens, dies, kettles, tanks, pipes, rolls, drums, ovens and air ducts. Lengths from 4 to 96 inches, widths from ¾ to 2½ inches, with cross section curving or lengthwise bending. Available with brazed-on fins.

Tubular Heaters . . . that clamp on, fit into machined grooves, cast into metals, immerse in liquids, install in ovens and ducts. Straight lengths or factory-formed to nearly any contour. Lengths from 6 inches to 30 feet. Triangular or round cross section. Available with brazed-on fins.

Cartridge Heaters . . . that smoothly fit standard drilled holes in dies, platens, molds, extrusion and injection barrels. Special leads available for protection against flexing action, abrasion, moisture or vapors. Diameters from ¾ to 1¹⁵⁄₁₆ inches, lengths from 1¾ to 25⅜ inches.

Versatile Chromalox electric heaters are available in sheath materials and wattages to match almost any application to 1100°F. Easy to install, they are fast, clean, safe and economical.

Your Chromalox Man can help you determine the one that best answers your specific problem. He's backed by the world's largest factory stock of industrial heaters, ready for immediate shipment. Why not give him a call. You'll find his phone number listed at the right.

Our new Catalog 60 provides detailed product information and suggests numerous applications for the complete line of Chromalox electric heaters for industry. If you have not yet received a copy, please let us know.

1601

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Electric Heat
INDUSTRIAL · COMMERCIAL · RESIDENTIAL
EDWIN L. WIEGAND COMPANY
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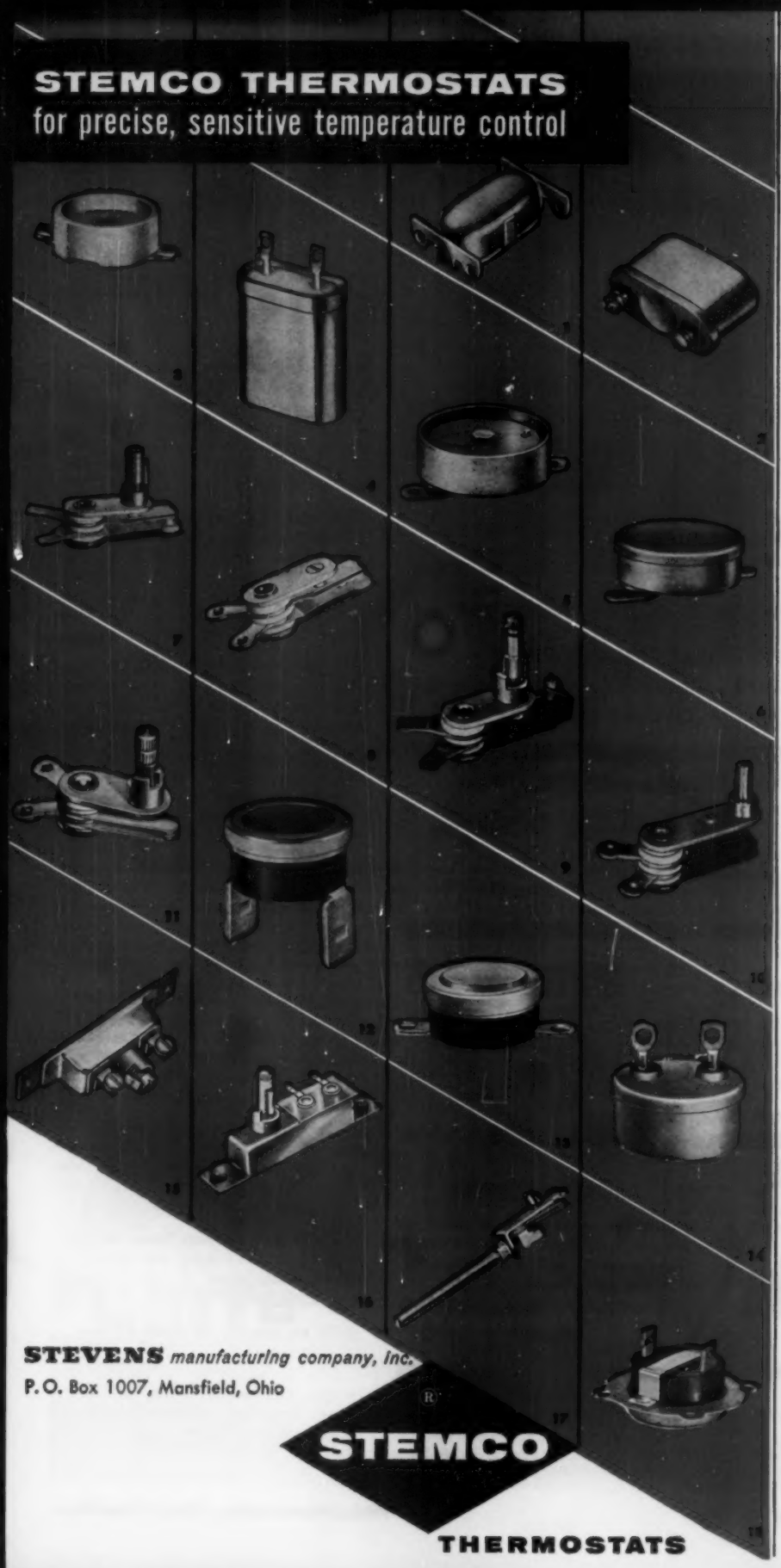
CIRCLE 453 ON READER SERVICE CARD→

STEMCO THERMOSTATS
for precise, sensitive temperature control



1, 2, TYPE C† *semi-enclosed* (1), *hermetically sealed* (2). Small positive acting with electrically independent bimetal strip for operation from −10° to 300°F. Rated at approximately 3 amps, depending on application. Hermetically sealed type can be furnished as double thermostat "alarm" type. Various terminals and mountings. Bulletin 5000.

3, 4, TYPE M*† *semi-enclosed* (3), *hermetically sealed* (4). Snap acting bimetal disc type for appliance and electronic applications from −20° to 300°F. Rated: 3 to 10 amps at 115 VAC and 28 VAC/DC. Available with a variety of mounting brackets, type of terminals and/or wire leads. Bulletin 6000.

5, 6, TYPE MX† *semi-enclosed* (5), *hermetically sealed* (6). Snap acting miniature units to open on temperature rise for missile, avionic, electronic and similar uses. Temperature 10° to 260°F, 2° to 6°F differential. Depending on duty cycle, rated: 1 to 3 amps, 115 VAC and 28 VAC/DC. Also available in ceramic bases and hermetically sealed HC-6/U cans, with various mounting brackets. Bulletin 6100.

7, 8, TYPE S*† *adjustable* (7), *non-adjustable* (8). Positive acting with single stud or nozzle mounting. Operation to 600°F. Rated at 15 amps at 115 VAC, 7 amps at 230 VAC. Spade, screw or formed terminals, various adjusting stems, etc. Bulletin 1000.

9, TYPE SA*† *adjustable* (9), *or non-adjustable.* Snap acting with electrically independent bimetal. Also single-pole, double throw. Single stud or nozzle mounting. Rated at 1650 watts at 115-230 VAC only. Spade or screw terminals. Bulletin 2000.

10, TYPE SM*† *manual reset.* Electrically same as Type SA (above) except for manual reset feature. Bulletin 2000.

11, TYPE B *adjustable* (11) *or non-adjustable.* For uses where heat generated by passage of current through bimetal strip is desirable. Various terminals, single stud or nozzle mounting. Operation to 400°F. Average rating 5½ amps, 115 VAC. Bulletin 9000.

12, 13, 14 TYPE A*† *semi-enclosed* (12, 13), *hermetically sealed* (14). Insulated, electrically independent bimetal disc gives fast response and quick, snap action control for appliance and electronic applications from −20° to 300°F. Lower or higher temperatures special. Depending on duty, rated: 4 to 13.3 amperes, 115 VAC and 28 VAC/DC. Various terminals and mounting brackets available. Bulletin 3000.

15, TYPE R*† *sealed adjustable* (15), *sealed non-adjustable.* Positive acting for operation to 600°F. Rated at 15 amps at 115 VAC, 4 amps at 230 VAC. Screw terminals. Bulletin 7000.

16, TYPE W*† *adjustable* (16), *or non-adjustable.* Snap action bimetal strip type for operation to 300°F. Depending on duty, rated: 5 to 10 amps, 115 or 230 VAC. Screw or nozzle mountings; spade or screw terminals. Bulletin 4000.

17, TYPE H† *adjustable.* Positive acting for fry pans, skillets, sauce pans, etc. Fail-safe, open in low to 500°F in high. Rated at 1650 watts at 115 VAC. Bulletin 10,000.

18, TYPE D* *automatic* (18), *or manual reset.* For laundry dryers or other surface and warm air applications. Snap acting disc type for operation to 350°F. Open or enclosed. Rated: 25 to 40 amps at 120-240 VAC. Screw or spade terminals. Bulletin 8000.

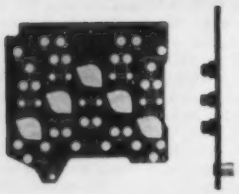
Illustrations, for general information only, do not necessarily show size comparisons. Fully dimensioned and certified prints on request. Manufacturer reserves right to alter specifications without notice.

*Refer to Guide 400 EB for UL or CSA approved ratings.
†These thermostats covered by patents issued or applied for.

STEVENS *manufacturing company, inc.*
P. O. Box 1007, Mansfield, Ohio

STEMCO®
THERMOSTATS

PRODUCT DIGEST from U.S. RADIUM



EDGE-LIGHTED PANELS

Special-purpose panels and dials accurate to MIL spec are available from United States Radium Corporation. Standard edge-lighted and integral edge-lighted products by Lackon® provide optimum legibility and contrast, with high resistance to humidity, surface abrasion.

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DIALS, PANELS AND NAMEPLATES

Metal dials and panels include a greater variety of finishes, colors and processes than ever before.

New lithographed nameplates and panels featuring special hard, abrasion-resistant finish are available with or without adhesive backing in various thicknesses.

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CATHODE-RAY TUBE PHOSPHORS

USR offers a variety of phosphors for TV and industrial cathode-ray tube applications.

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Specially-fabricated isotope sources—Ni^{63} plated electrodes and radium foil—are now being produced as ionization sources for electron tubes.

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New 360° light source and high-brightness one-way lamps use luminescent bulbs energized by Kr^{85} gas. Units visible at 500-2000 ft., depending on model, size, color; service life to 10 years. New Isolite markers, signs and placards now available.

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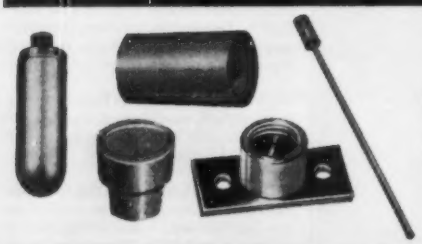

RADIATION SOURCES

Sealed beta, gamma and neutron sources for research, gauging, radiography and related applications are available with varying intensities and energies. Circle 606, 607, 608 on Reader Service Card.

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catalogs and bulletins.....continued

(I-63) **Wire and Cable**—Brochure, 8 pp. Gives sizes and rates of silicone rubber insulated wires, cable and heating cable. Rockbestos Wire & Cable Co, Div of Cerro de Pasco Corp, Nicoll & Canner Sts, New Haven, Conn.

(I-64) **Insulation**—Brochure, 8 pp. Gives tensile and dielectric strength, special properties of composite laminated electrical insulation. Chase-Foster, Inc, 34 Ormsbee Ave, Providence, RI.

(I-65) **Switches and Counters**—Data sheets, 18 pp. Describes binary and digital thumbwheel switches, rotary selector switches with removable printed circuits, counters. Chicago Dynamic Industries, Inc, Precision Products Div, 1725 Diversey Blvd, Chicago.

(I-66) **Wire and Cable**—Brochure, 6 pp. Presents specifications for military hook-up wire, silicone rubber insulated wire, coaxial cable, military aircraft wire and cable, multiconductor cable, and appliance wire. William Brand-Rex Div, American Enka Corp, 31 Sudbury Rd, Concord, Mass.

(I-67) **Dc Power Supplies**—Bulletin, 8 pp. Describes units with up to 1500 amps output using silicon rectifiers. Christie Electric Corp, 3410 W 67 St, Los Angeles.

(I-68) **Electronics Components**—Catalog, 80 pp. Describes wire wound and composition element potentiometers, switches, resistors, rheostats, decade box. Clarostat Mfg Co, Inc, Dover, NH.

(I-69) **Diodes and Transistors**—Fourteen bulletins, 21 pp. Provides dimensioned drawings, characteristics, sample circuits for germanium and silicon diodes; germanium power transistors. Clevite Transistor Products, 241 Crescent St, Waltham, Mass.

(I-70) **Passenger Car Electrical Products**—Catalog, 64 pp. Contains descriptions of switches, connectors, pilot and dash lamps, terminals, circuit breakers, plugs and sockets, wiring accessories. Cole-Hersee Co, 18 Old Colony Ave, Boston, Mass.

(I-71) **Film Capacitors**—Brochure, 4 pp. Gives dimensions and ratings of capacitors for close tolerance and stability requirements. Component Research Co, Inc, 3019 S Orange Dr, Los Angeles 16.

(I-72) **Magnetic Memory Drum**—Brochure, 4 pp. Describes features and applications of 15,000 bit drum. Consolidated Controls Corp, Bethel, Conn.

(I-73) **Electronic Connectors**—Catalog, 20 pp. Provides mechanical and electrical ratings, dimensions for multicontact connectors used in communications equipment, computers, aircraft. Continental Connector Corp, 34-63 56 St, Woodside 77, NY.

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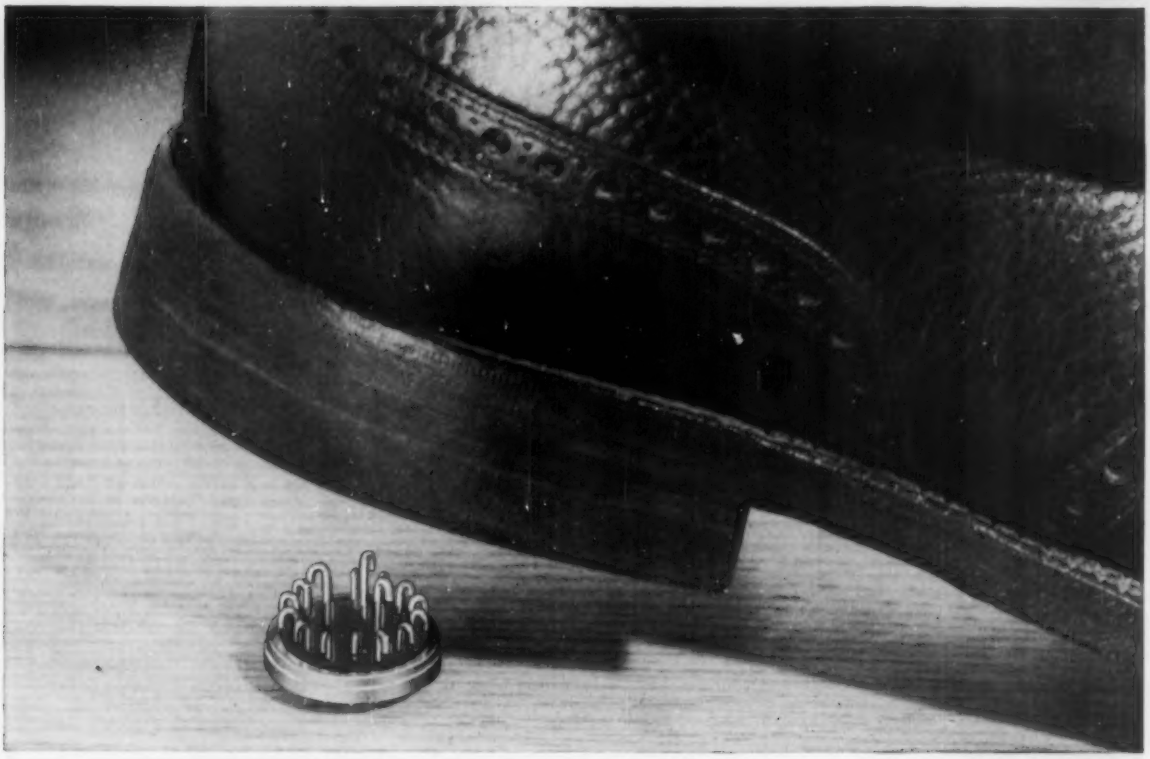

A real heel might test a Fusite Terminal like this

...but he won't make it leak!

The adherence between glass and metal in a Fusite Hermetic Terminal is an easily demonstrated fact. There are several theories as to *why* our exclusive V-24M glass actually chemically bonds to the metal components. Cobalt and certain other metallic oxides in the glass oxidize the iron in the metal which is taken into solution. It is believed that through the solution of iron, a gradual decrease of the difference of thermal expansion between the glass and metal takes place at the glass-metal interface. This inter-fusion of the two dissimilar materials gives Fusite Terminals their ability to withstand great mechanical and thermal shock and still pass Statiflux tests for glass cracks, hydrostatic pressure tests and helium mass spectrometer leak detection.

This fusion is reinforced by a strong compression of the metal ring around the glass made possible by a favorable thermal expansion balance of the glass, pins and housing.

The combination of fusion and compression provides a terminal so rugged that leaker rejection rate of components into which our terminal is fabricated is practically nil, even when roughly handled and subjected to extreme temperature changes.

Samples for your own testing are yours for the asking.
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INSULATE ELECTRICALLY
GLASS TO METAL
FUSITE
TERMINALS
PROTECT PRODUCT PERFORMANCE
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CIRCLE 455 ON READER SERVICE CARD 455

RELAYS SWITCHES

AUTOMATIC ELECTRIC

AE RELAYS

	SERIES	OPERATING TIME, SECONDS	RELEASE TIME, SECONDS
CLASS B When extremely long service and reliable operation are demanded, this relay meets the requirements. Life often exceeds 400 million operations. Ideal for computers, fire control, pulsing or switching functions.	BQA	0.002-0.030	0.005-0.050
	BSO	0.040-0.120	0.025-0.350
	BSR	0.004-0.035	0.035-0.600
	BSA	0.020-0.055	0.035-0.600
	BFA	0.010-0.025	0.008-0.020
	BMS	0.010-0.030	0.015-0.050
CLASS E A new telephone-type relay, designed for long-life industrial service. Based on the rugged Class B design, this is a universal relay, engineered for a variety of uses demanding compact size coupled with our usual high standard of reliability.	EQA	0.002-0.030	0.005-0.025
	ESO	0.015-0.050	0.025-0.125
	ESR	0.005-0.030	0.025-0.125
	ESA	0.015-0.030	0.050-0.125
	EFA	0.005-0.025	0.005-0.025
	EMS	0.010-0.030	0.015-0.030
CLASS A This original telephone-type relay will hold down costs, yet provide dependable operation and long life. A wide variety of coils, contacts, contact spring arrangements and mounting facilities makes this truly the "all-purpose" relay.	AQA	0.002-0.025	0.005-0.025
	ASO	0.040-0.120	0.020-0.250
	ASR	0.004-0.025	0.020-0.350
	ASA	0.010-0.050	0.020-0.350
	AWS	††Up to 2	0.005-0.025
	AVR	0.002-0.025	††1 to 15
	AMC	0.210-0.280	0.300-0.345
CLASS C This compact relay combines unusual dependability and surprisingly long service life in a space about half of the size of the average relay of equal rating. Can be used for high-speed or delayed operation.	CQA	0.005-0.035	0.005-0.025
	CSA	0.010-0.040	0.015-0.200
	CMS	0.010-0.035	0.010-0.050
CLASS S Specify this relay for aircraft use, where a small, light relay is required, resistant to shock and vibration. It features fast pulse response because of its small mass and slight self-inductance. Series SQPC available for printed circuits.	SQA	0.002-0.016	0.005-0.085
	SQD	0.002-0.030	0.005-0.085
	SQPC	0.002-0.030	0.005-0.085
	S-Power	0.005-0.016	0.005-0.010
CLASS Z Choose Class Z relays where a small, light relay is needed but long life or time delay is of greater importance than extremely small size. Similar to Class A relay, but smaller and less sensitive.	ZQA	0.002-0.025	0.005-0.025
	ZSO	0.010-0.050	0.050-0.150
	ZSR	0.003-0.010	0.050-0.200
	ZSA	0.010-0.040	0.050-0.200
	ZMS	0.010-0.040	0.005-0.200
	ZFA	0.010-0.025	0.008-0.020
	Type 18 (Aircraft)	0.002-0.025	0.005-0.025
CLASS F An a.c. relay, for use when the number of relays doesn't justify a rectifier, and when operate and release time delays are not a factor. When operate and release timing is required, an inexpensive rectifier can be used with any of the above d.c. relays.	FQA	0.002-0.025	0.005-0.040
	BFA	0.010-0.025	0.008-0.020
	EFA	0.005-0.025	0.005-0.025
	FMS	0.002-0.020	0.002-0.020
	FMC	0.298-0.333	0.290-0.350
	ZFA	0.010-0.025	0.008-0.020
POLARIZED Series PHD and PLD offer "2-position" or "3-position" operation; Series PTW provides "2-position" only. "2-position" relays "stick" operated until current is reversed; "3-position" have neutral position in absence of current.	PLD	0.003-0.010	0.022-0.047
	PHD	0.006-0.027	0.065-0.075
	PTW****	0.007 Minimum	0.0002 Approx. Travel Time
SPECIAL PURPOSE—We can usually make assemblies of Automatic Electric relays with modifications to suit your special applications. The Class E Video relay, illustrated here, is an example. Others are designed for power applications, electro-mechanical interlocking, marginal operation, mechanical locking, micrometer adjusting, and the simultaneous closing of up to 35 circuits (BAR relay).			

AE STEPPING SWITCHES

FAST STEPPING, SMOOTH RUNNING, POSITIVE STOPPING

TYPE 44

The Type 44 is a small switch with a large, flexible capacity. Use this switch in almost any d.c. application—for impulse controlled response or self-interrupted operation. Though it's only slightly larger than a pack of king-size cigarettes, the Type 44 rotary stepping switch accommodates up to six 10-point bank levels.

TYPE 45

In every feature of its design, the Type 45 rotary stepping switch provides for adaptation to varied requirements, including a.c. operation. The one-piece, open-type flat frame occupies only one side of this switch, so the 25-point contact banks can be built up level by level as needed, up to twelve.

SERIES OCS RELAY

Here's a shock-resistant relay which can be used for cam-switching...for alternate on-off operations...or as a "stepper." When you order Automatic Electric's OCS relay, you specify the programming. This compact unit simplifies engineering and wiring—cuts space, weight and maintenance costs.

RELAYS **SWITCHES**

AUTOMATIC ELECTRIC

SERIES	MAXIMUM COIL VOLTAGE	MAX. NO. OF STANDARD CONTACTS	TYPE OF CONTACTS†††	WEIGHT	DIMENSIONS (MAX.) IN.
BQA	250 dc	24 Spgs.	Code 0—18 ga. Twin	8-12 oz.	4-3/32x2-5/16x1
BSO	135 dc	**24 Spgs.		8-14 oz.	4-3/32x2-5/16x1
BSR	135 dc	*6 Spgs.		8-14 oz.	4-3/32x1-7/8x1
BSA	250 dc	*6 Spgs.		8-14 oz.	4-3/32x1-7/8x1
BFA	230 ac	24 Spgs.		8-14 oz.	4-3/32x2-5/16x1
BMS	250 dc	***2 Form C	Snap-action	7-11 oz.	4-3/32x2-17/32x1-23/32
EQA	220 dc	26 Spgs.	Code 0—18 ga. Twin	2-3 oz.	2-1/4x1-23/32x1-1/8
ESO	115 dc	26 Spgs.			
ESR	115 dc	*6 Spgs.			
ESA	220 dc	*6 Spgs.			
EFA	220 ac	12 Spgs.			
EMS	220 dc	2 Form C	Snap-action		2-1/4x1-23/32x2-3/16
AQA	250 dc	26 Spgs.	Code 4—18 ga.	8-12 oz.	4-3/32x2-3/16x1-7/16
ASO	135 dc	26 Spgs.		8-14 oz.	4-3/32x2-3/16x1-7/16
ASR	135 dc	*6 Spgs.		8-12 oz.	4-3/32x2x1-7/16
ASA	250 dc	*6 Spgs.		8-12 oz.	4-3/32x2x1-7/16
AWS	250 dc	1 Form A		7-11 oz.	4-3/32x2-3/4x1-7/16
AVR	250 dc	Special		8-12 oz.	4-1/4x2x1
AMC	250 dc	2	Mercury	12-16 oz.	4-3/4x3-1/16x3
CQA	150 dc	12 Spgs.	Code 0—18 ga. Twin	4-oz.	4-1/32x2-3/16x21/32
CSA	150 dc	12 Spgs.	Code 0—18 ga. Twin	4-oz.	4-1/32x2-3/16x21/32
CMS	150 dc	1 Form C	Snap-action	6-oz.	3-13/16x2-7/16x1
SQA	†115 dc	9 Spgs.	Code 0—20 ga. Twin	2-oz.	1-17/32x2x11/16
SQD	†115 dc	18 Spgs.		2- 3 oz.	1-17/32x2x1
SQPC	†115 dc	18 Spgs.		2- 3 oz.	1-17/32x2x1
S-Power	115 dc	1 Make	Silver-Tungsten	12 oz.	1-1/2x1-1/2x1-1/4
ZQA	135 dc	13 Spgs.	Code 4—18 ga.	4- 6 oz.	2-1/2x2-3/4x1-1/2
ZSO	115 dc	13 Spgs.		4- 6 oz.	2-1/2x2-3/4x1-1/2
ZSR	115 dc	*6 Spgs.		4- 6 oz.	2-1/2x2-3/4x1-1/2
ZSA	135 dc	*6 Spgs.		4- 6 oz.	2-1/2x2-3/4x1-1/2
ZMS	135 dc	***2 Form C	Snap-action	8-10 oz.	2-1/2x2-5/8x2-1/4
ZFA	115 ac	13 Spgs.	Code 4—18 ga.	4- 6 oz.	2-1/2x2-3/4x1-5/16
Type 18 (Aircraft)	135 dc	13 Spgs.	Code 4—18 ga.	4- 6 oz.	2-1/2x2-1/4x1-1/4
FQA	To 230 (16-66 cycles)	12 Spgs.	Code 4—18 ga.	9-13 oz.	4x1-15/16x1-1/4
BFA	To 230 (20-60 cycles)	24 Spgs.	Code 0—18 ga.	8-14 oz.	4-3/32x2-5/16x1
EFA	To 220 ac	12 Spgs.	Code 0—18 ga.	2- 3 oz.	2-1/4x1-23/32x1-1/8
FMS	To 240 (16-66 cycles)	2 Form C	Snap-action	10-14 oz.	3-1/2x2-3/8x2-3/8
FMC	To 240 (16-66 cycles)	2	Merc.-Glass	14-18 oz.	4-5/8x2-3/4x2-3/4
ZFA	To 115 (20-60 cycles)	13 Spgs.	Code 4—18 ga.	4- 6 oz.	2-1/2x2-7/8x1-11/32
PLD	350 dc	6 each side	Code 4—18 ga.	28 oz.	4x3-1/4x2
PHD	350 dc	6 each side	Code 4—14 ga.	27-37 oz.	4-13/16x2-3/4x3
PTW****		1 Form C	Tungsten Carbide or Palladium	14 oz.	2-7/8x2-1/4x3-5/16

*More contacts can be used at a sacrifice of speed.
**Up to 0.600 sec. release time on BSO relay with 6 springs max.
***With 1 snap-action switch and 1 contact assembly (8 springs max.)
****Octal or pin-type plug (to fit WE Co. 255 applications) available.
†Higher wattage obtainable with oversize coils.
††Timing value in conjunction with a Series ASO relay.
†††Most relays can be furnished with special heavy-duty contacts.

Automatic Electric, pioneer in the use of telephone-type relays for industry, has the experience, reputation, manufacturing facilities, research staff, and down-to-earth, practical "know how" to solve your knottiest control problem. We specialize in the hermetic sealing of relays and switches, as well as in the design, circuitry and assembly of industrial control "packages" and systems. Our representative and facilities are at your command.

SALESMEN

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SAN FRANCISCO, CALIF.
UPPER DARBY, PA. (Philadelphia suburb)

*District Office

Check the Yellow Pages of your telephone directory to get in touch with our representative in your area. Address all Home Office inquiries to: Director, Industrial Control and Equipment Sales.

We will be happy to send additional literature on request. You may be interested in some of the following:

Rotary Stepping Switches.....#1698-H
Relays for Industry.....#1702-E
Relay Terms.....#1884
Basic Circuits.....#1927
AE Enclosures.....#4083
Key Switches and Other Electrical Control Components.....#4018-E

Address requests to:
Director, Industrial Control and Equipment Sales, Northlake, Illinois

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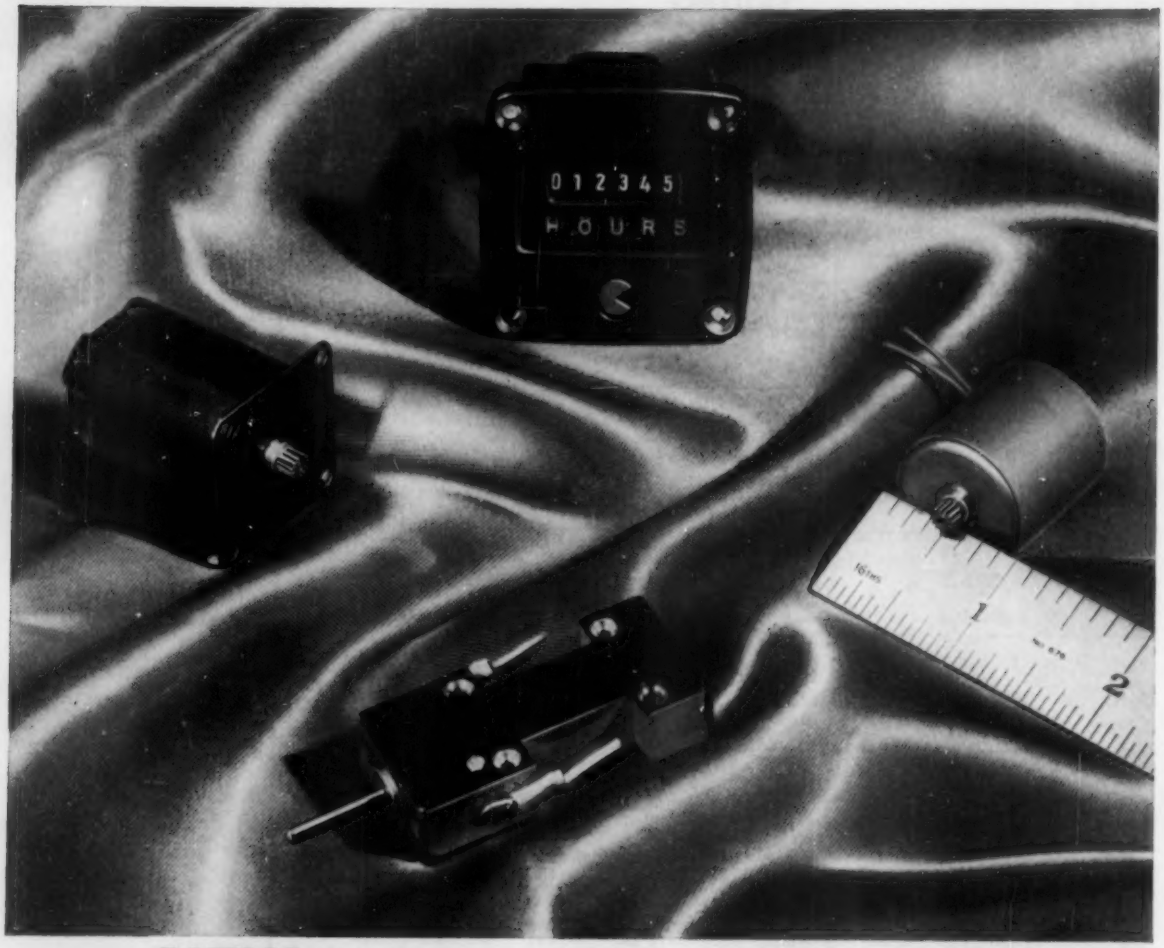
CIRCLE 457 ON READER SERVICE CARD 457



NEW Cramer miniatures for military use record elapsed time, - drive positioning devices

TYPE 620 Elapsed Time Indicator (top) shown approximately full scale, is offered for operation on 115 volt, 60 or 400 cycle power. Dimensionally, the version illustrated meets MS-28053 and NEMA standards, and is front-panel mounted through a 1-19/32" diameter opening. All relevant test requirements of MIL-M-7793B and MIL-E-5272B are met or exceeded (to 50 G's shock, 2000 cycle vibration). An optional back-panel mounting adapts to existing panel drilling. Hermetically sealed, Type 620 has recessed solder lugs at rear for electrical connections. Total registration 9,999.99 hours, weight about 4 ounces. Designed primarily for military use, the unit will give unsurpassed service in rugged industrial applications.

TYPE 120 Miniature AC Motor (right) is rated 115 volts, 60 cycles. Permanent-magnet design assures fast response and truly synchronous operation. Running torque .08 inch ounce at 240 rpm rotor speed, weight approximately 2 ounces.

TYPE 821 Ungoverned DC Motor (bottom) for no-load speeds from 8,000 to 20,000 rpm. Typical 28-volt armature develops 14,200 rpm no-load, 12,600 rpm at 0.1 inch ounce load, with current drain about 100 ma. Weight under 2 ounces. Meets MIL-T-5422E.

TYPE 890 115-Volt 400-Cycle Motor (left) is a single-phase hysteresis-synchronous motor. Available as basic ⅞" motor (like Type 120 at right), or in 1-inch flange-mounted can illustrated, containing motor and capacitor network. Produces .01 inch ounce torque at 3000 rpm. Weight under 2 ounces.

Write for complete information, specifications.

ELECTROMECHANICAL DIVISION

CRAMER CONTROLS CORPORATION

CENTERBROOK, CONNECTICUT

To simplify your design problems—

COMPLETE ENGINEERING AND SAMPLE SERVICE PLUS A NATIONWIDE NETWORK OF FIELD ENGINEERS—

E-I glass-to-metal seals are the industry standard for dependability . . . have been service-proven on vital space age projects and in critical commercial equipment. If you have a seal problem ask E-I for a recommendation. Sales engineers are located in all principal cities.

1. STANDARD SEALS—The most complete range of economical standard seals affords widest design latitude. Includes single lead terminals, headers, miniature closures and threaded end seals.

2. SPECIAL SEALS—For unusual requirements, E-I engineers will design seals to specifications or modify standard types for your particular application. Complete engineering facilities available.

3. CUSTOM SEALING—Complete facilities for sealing components or assemblies of your own manufacture. Send samples or drawings for quotations. Fast service on reasonable quantities.

Patented in Canada, No. 523,390; in United Kingdom, No. 734,583; licensed in U. S. under No. 2561520

ELECTRICAL INDUSTRIES

A Division of Philips Electronics & Pharmaceutical Industries Corp.

MURRAY HILL, NEW JERSEY

CIRCLE 459 ON READER SERVICE CARD 459

GRAPHALLOY

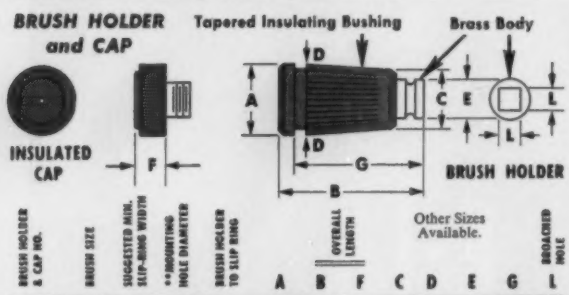
SILVER GRAPHALLOY BRUSHES and BRUSH & SLIP-RING ASSEMBLIES . . .

GRAPHALLOY BRUSHES

are used on such equipment as . . . SERVO SYSTEMS • SYNCHROS • CHOPPERS • RADAR • GYROS • INVERTERS • THERMOCOUPLE and STRAIN GAGE CIRCUITS • GUIDED MISSILES • PULSE SYSTEMS • DIGITAL COMPUTERS • WAVE GUIDES • SONAR • TRANSDUCERS • TORQUE INDICATORS

Silver GRAPHALLOY Brushes have been widely used because *of* LOW *and* CONSTANT CONTACT DROP, EXTREMELY LOW ELECTRICAL NOISE *and* LONG LIFE. Over 200 grades are now serving in a wide variety of applications. Silver GRAPHALLOY Brushes on ½"-diameter coin silver slip rings have operated successfully in highly critical electrical circuits at speeds up to 100,000 R.P.M. *Our Engineering Department will assist in determining the exact grade of* GRAPHALLOY *for your needs.* Ask for our Brush Inquiry Form 109.

BRUSH HOLDER and CAP



BRUSH HOLDER & CAP NO.	BRUSH SIZE	SUGGESTED MIN. SLIP-RING WIDTH	**MOUNTING HOLE DIAMETER	BRUSH HOLDER TO SLIP RING	A	B	F	C	D	E	G	L
					OVERALL LENGTH			Other Sizes Available.				BROACHED HOLE
14326	⅛" sq.	3/16"	13/32"	1/16" min.	.437"	⅞"	3/16"	.404"	.418"	.281"	25/32"	.129"
11509†	5/32" sq.	3/16"	13/32"	1/16" min.	.437"	⅞"	3/16"	.404"	.418	.281"	25/32"	.160"
11570†	3/16" sq.	¼"	7/16"	1/16" min.	.484"	⅞"	3/16"	.441"	.451"	.313"	25/32"	.192"
11527†	¼" sq.	5/16"	9/16"	⅛" min.	.616"	1 5/16"	3/16"	.561"	.573"	.438"	1 3/16"	.256"

†Shunts are provided. **Mounting hole diameter for brush holder dimension D.

Request and fill in Brush Inquiry Sheet, Form 109, so that we can supply the proper grade of brush material.

SLIP RINGS
Solid Coin Silver

Standard Coin Silver Slip Rings, both *cylindrical* and *flat* types, are illustrated at right. We recommend the cylindrical type rings with three brushes per ring . . . spaced at 120°. The cylindrical type are designed for press fitting over standard steel shafting. The flat type rings are designed for nesting either on an insulated plate or for molding into insulation. Insulated slip rings of either type or slip-ring assemblies can be furnished with leads attached.

No. 168 Series flat type to 20" O.D.

Standard "Flat" rings have ¼" radial contact surface and ⅛" radial spacing between adjacent rings.

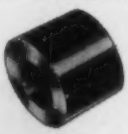
No. 116 Series cylindrical type to 36" O.D.

Copper Slip Rings, flat or cylindrical, are available.

BRUSH ASSEMBLIES

GRAPHALLOY, because of its inherent, non-welding and arc-quenching characteristics, is used widely for contacts . . . especially where positive breaking of a circuit is required.

BUSHINGS
Oil-free



Replace oil-lubricated bushings in synchros, instruments, timers and missiles.

Advantages: 1) Lower friction at room temperatures. 2) No oil to solidify at low temperatures. 3) No oil to carbonize at prolonged elevated temperatures.

*Ask for Data Sheets 270 and 277 on Miniature Bronze-*GRAPHALLOY *Bushings.*

CONNECTORS
(garter springs)

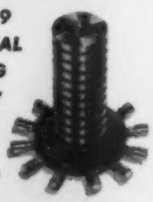
These silver-plated coil spring Connectors make for positive electrical connection to the brass body of the brush holder by snapping into the groove on the holder. The connecting lead can be pre-soldered to the Connector.

GARTER SPRING CONNECTORS	BRUSH SIZE	BRUSH HOLDER NO.
127-9	⅛" sq.	14326
127-9	5/32" sq.	11509
127-10	3/16" sq.	11570
127-14	¼" sq.	11527

CLUTCH FACINGS and CLUTCH GEAR ASSEMBLIES

Torque remains same within close operating limits despite changes in temperature and humidity. For instrumentation, guided missiles, constant friction devices.

Model 319 CYLINDRICAL SLIP-RING assembly



Solid Coin Silver Rings

MODEL	RINGS	LENGTH
319-4	4	2 9/16"
319-6	6	3 9/16"
319-10	10	4 13/16"
319-14	14	6 5/16"

Slip-ring O.D. 1⅝". Terminal O.D. 4".
Assembly I.D.: .814"/.813"
Range: Same as for Model 399

Model 409 FLAT SLIP-RING assembly

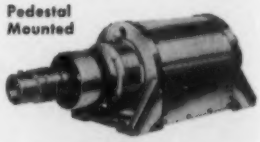
Solid Coin Silver Rings

MODEL	RINGS	OVERALL O.D.—"A"
409-2	2	5½"
409-4	4	7"
409-6	6	8½"
409-10	10	11½"

Hub O.D. 2"; I.D. 1.573"/1.571"; Length 1⅛". To 5 amperes, 125 volts.
More rings available upon application.

Model 399 BRUSH and SLIP-RING assembly

Pedestal Mounted



MODEL	RINGS	bell slot distances CL to CL WIDTH	bell slot distances CL to CL LENGTH	**OVERALL LENGTH
399-4	4	4½"	7¾"	13¼"
399-6	6	4½"	8½"	14"
399-10	10	4½"	10"	15½"
399-14	14	4½"	11½"	17"

**To outer end of coupling.

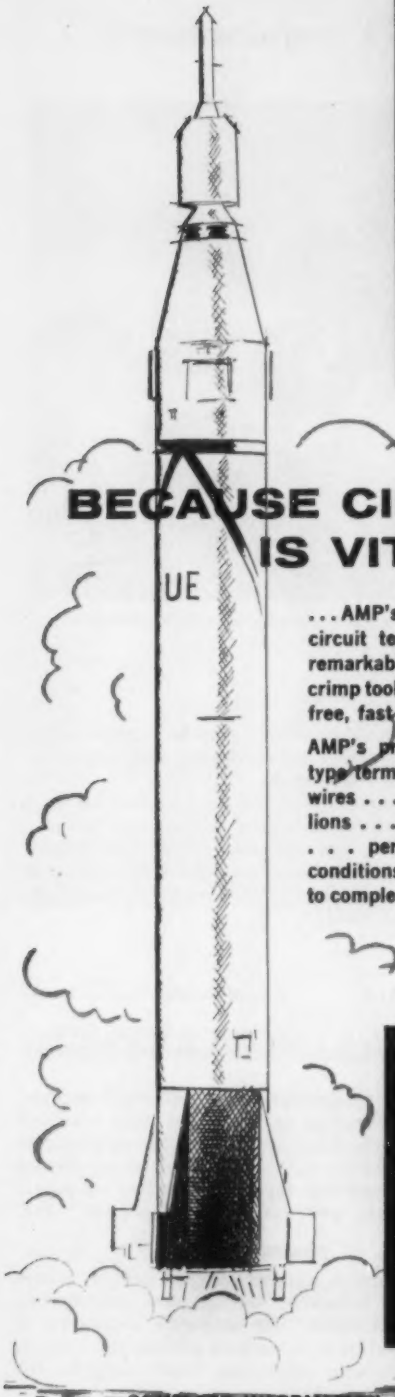
Specifications: Width 6½"—Height 6½". Shaft CL above base 3¼".
Applications: from strain gage or thermocouple up to 5 amperes, 125 volts, 250°F.
Speeds to 5,000 RPM.
Three Silver-GRAPHALLOY Brushes per solid coin silver slip ring.
Extraneous noise level extremely low.
Rugged in design and construction.
Readily connected mechanically and electrically.
Complete coupling provided for 15/16" shaft.
More rings and higher speeds available upon application.

Write for data sheets

CALL ON OUR OVER 40 YEARS OF DESIGN EXPERIENCE FOR HELP IN SOLVING YOUR BRUSH PROBLEMS!

GRAPHITE METALLIZING CORPORATION : 1011 NEPPERHAN AVENUE YONKERS, NEW YORK

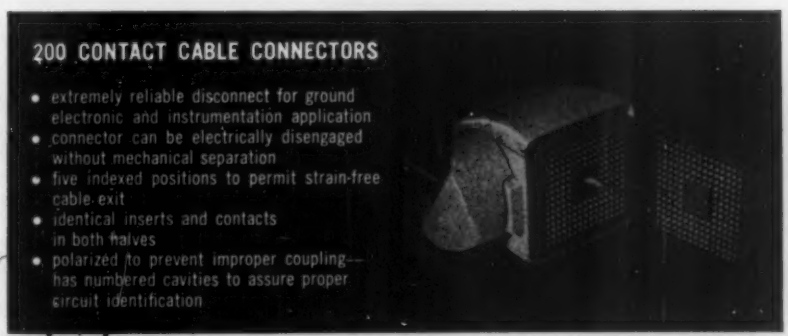
CERTI-SEAL SPLICES
AMPLI-NYL TERMINALS AND SPLICES
• combined wire size range 22-2/0 AWG
• exceed millivolt-drop specifications
• finest nylon pre-insulation
• shock and corrosion resistant
• color coded by wire size



BECAUSE CIRCUIT RELIABILITY IS VITAL . . .

. . . AMP's product is more than fine circuit terminals . . . more than remarkably precise compression-crimp tooling . . . more than an error free, fast method of attachment.

AMP's product is finished crimp-type terminations on your circuitry wires . . . by the hundreds or millions . . . of the highest reliability . . . performing under gruelling conditions . . . from basic terminals to complete patchcord systems.


200 CONTACT CABLE CONNECTORS
• extremely reliable disconnect for ground electronic and instrumentation application
• connector can be electrically disengaged without mechanical separation
• five indexed positions to permit strain-free cable exit
• identical inserts and contacts in both halves
• polarized to prevent improper coupling—has numbered cavities to assure proper circuit identification

COMPLETE INFORMATION ON THESE FOUR PRODUCT LINES IS AVAILABLE ON REQUEST.

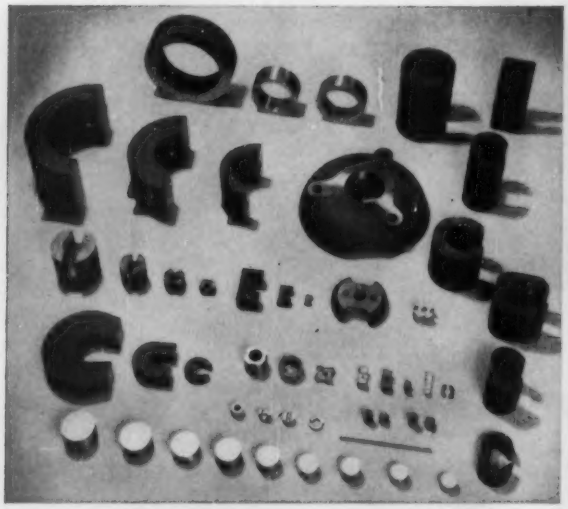
AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Japan

CIRCLE 461 ON READER SERVICE CARD 461

Specify "ARNOLD" for your PERMANENT MAGNET requirements



Typical group of Arnold permanent magnets, both cast and sintered types.

Typical group of permanent magnet assemblies, aluminum jacketed.

ALNICO MAGNETS

Arnold permanent magnets are available in all types of Alnico material, in sizes ranging from large castings weighing over 80 pounds to very small sintered parts weighing less than one gram.

Alnico V can usually be depended upon to deliver the greatest energy product to the magnetic circuit per unit weight of magnet material. It is therefore generally the first choice for a magnetic material except where special physical considerations are paramount.

Special assemblies such as rotors, traveling wave tube magnets, magnetron magnets, etc. may be supplied in an aluminum jacket to facilitate mounting and supply an added protection to the magnet.

Large magnet assemblies may also be supplied for mass spectrometer and other measuring applications where a high degree of stability and uniformity of field is required.

Many sizes and types of Alnico magnets are carried in stock for immediate delivery. For more information, *write for Bulletin GC-106C.*

SPECIAL PERMANENT MAGNET MATERIALS

ARNOX III

Arnox III is a molded-type magnet having high coercive force and moderately low residual induction and energy product. Principal uses are for magnetic requirements which are not stringent, and for a relatively short magnet of reasonable cross section. Accurate dimensions and close tolerances can be economically obtained. These magnets can be premagnetized before assembly, and have very high resistance to demagnetization. Slightly better magnetic properties are obtained in the pressing direction than in other directions.

ARNOX V

Arnox V is a ceramic permanent magnet material composed of highly oriented barium ferrite. It has many times the energy product of Arnox III and is comparable in many applications to Alnico V. Because of its high coercive force, its use is recommended in applications where a short magnetic length is desirable or where extremely high demagnetizing forces may be encountered. In many applications, it may be magnetized prior to assembly.

VICALLOY

Vicalloy is a carbon-free permanent magnet alloy containing about 10% vanadium, 50% cobalt and the balance iron.

Vicalloy may be fabricated in the form of castings, hot rolled bars and forgings, or cold rolled strip, wire and tubing. After suitable heat treatment, the material is quite readily machinable. Vicalloy is available on special order in bar, strip and thin tape for recording purposes. *For more information, write for "The Magneteer," Vol. 2, No. 1.*

CUNIFE

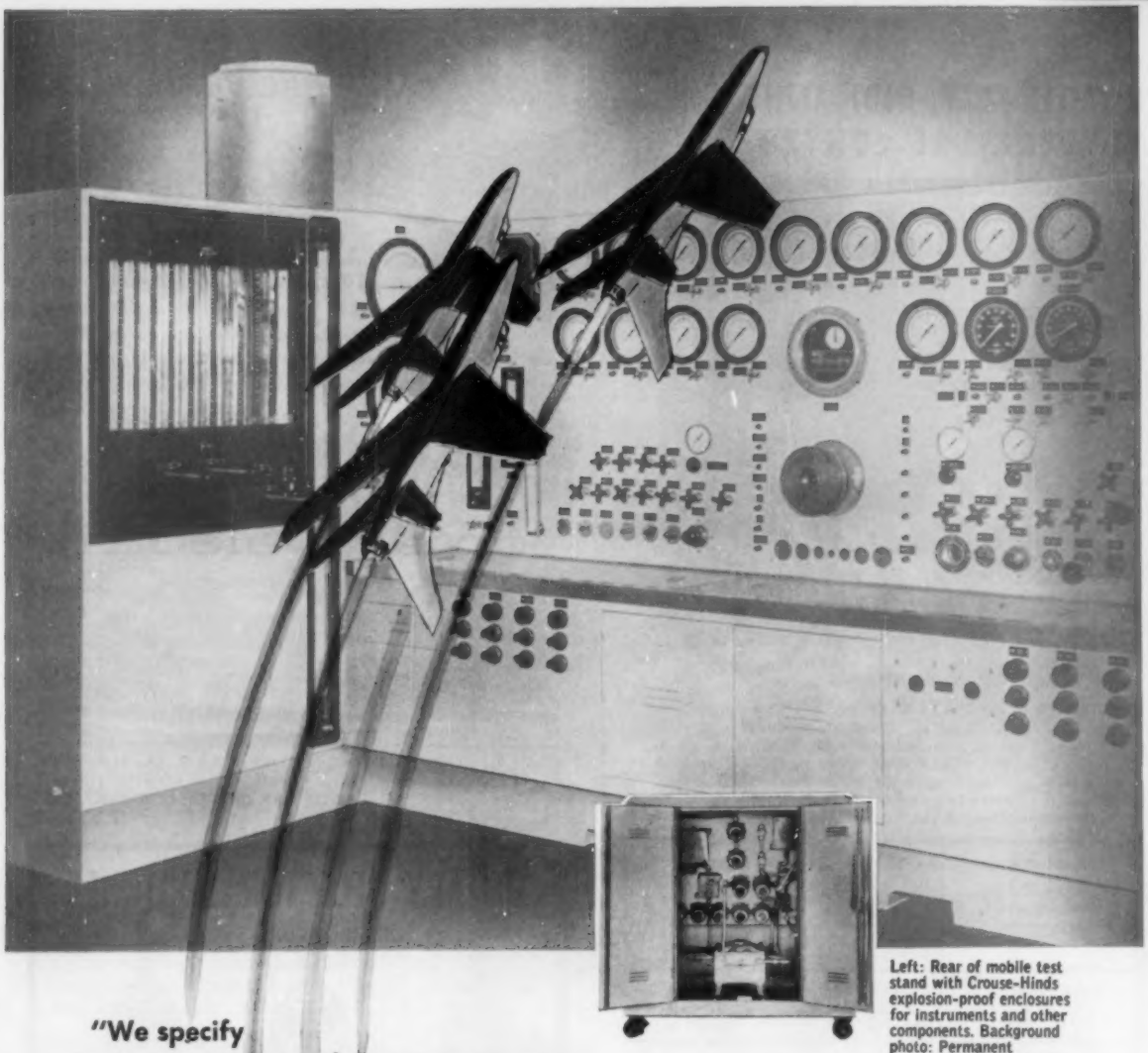
Cunife is a permanent magnet alloy of copper, nickel and iron which is malleable, ductile and machinable, after final heat treatment. The magnetic properties of Cunife are developed by cold working and are directional, with the best magnetic properties found only in the smaller sizes of rods or wires.

7806

ARNOLD

SPECIALISTS in MAGNETIC MATERIALS

THE ARNOLD ENGINEERING COMPANY, Main Office: MARENGO, ILL.
BRANCH OFFICES and REPRESENTATIVES in PRINCIPAL CITIES



Left: Rear of mobile test stand with Crouse-Hinds explosion-proof enclosures for instruments and other components. Background photo: Permanent test-stand installation.

"We specify

CROUSE/HINDS

Explosion-Proof Equipment

for our jet-engine fuel-test stands"

FLIGHT SUPPORT INC.

says Flight Support, Inc.
Metuchen, New Jersey

"Our Fuel Test Stands handle highly volatile and ignitible fuels. They must be completely explosion-proof throughout . . . particularly the electrical components.

"We specify Crouse-Hinds Explosion-Proof Electrical Equipment for two reasons: Their wide range of equipment gives us just what we want. And their technical assistance in applying their products to our specific needs fills our requirements in every detail.

"We are satisfied with the performance of this equipment for a very good reason—because our customers are satisfied."

For the product selection and technical assistance that helps build customer satisfaction, call any of the Crouse-Hinds offices listed below. If you do not have our catalog, ask for it during your call . . . or write us direct.

CROUSE HINDS
SYRACUSE NEW YORK

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RESIDENT REPRESENTATIVES: Albany Baltimore Reading, Pa. Richmond, Va.
Crouse-Hinds of Canada, Ltd., Toronto, Ont. Domex, Mexico City, D.F. Peterco, Sao Paulo, Brazil

CIRCLE 463 ON READER SERVICE CARD 463

REMOTE BULB, INDICATING TEMPERATURE CONTROL E32N

Featuring Control Point Accuracy Equivalent to Individually Calibrated Instruments

The **UNITED ELECTRIC** Type E32N Temperature Control is a uniquely designed instrument that is used to control and indicate temperatures of gases, liquids or hot plates over wide ranges. This unit contains a 12-inch scale for easily read visual indications. It is possible to replace the thermal unit in the field without any loss of calibration accuracy.

Temperature Ranges	—150°F. to 150°F., 70°F. to 370°F., 100°F. to 650°F. Read temperature on continuous, 12-inch indicating scale that rotates against a fixed index pointer in a vertical and centered location.
Switch Ratings	Up to 15 amps. at 115 or 230 volts A.C. 20 amp. A.C. or D.C. switches also available.
Switch Types	N.O., N.C., or Double Throw — no neutral position.
On-Off Differential	Approximately 1.0°F. or 2.0°F. dependent on model.
Adjustment	Calibrated dial rotated against a fixed index.
Calibration	Calibrating mechanism permits precise matching of scale to individual tolerance errors of thermal assemblies.
Compensation	Automatic compensation for ambient temperatures.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. For applications requiring custom-built units or modified standard units, call upon a UE application engineer for recommendations. Complete data is available for the Type E32N as well as for all standard UE controls.*

United Electric Controls COMPANY
85 SCHOOL STREET, WATERTOWN, MASS.

these are quality relays...

We put a lot of quality in our relays. We start with skilled design and quality materials. Then we add precision workmanship, modern production techniques and rigid inspection. The resulting relays are top quality units, outstanding in performance, dependable in operation. This extra quality you get from Comar costs no more, but it does pay big dividends. Next time you need quality relays—

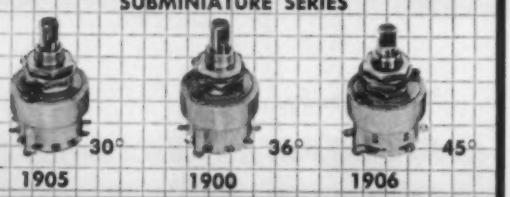
here is where to get them

comar electric

3349 ADDISON STREET • CHICAGO 18, ILLINOIS
RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING
CIRCLE 667 ON READER SERVICE CARD

ROTARY SELECTOR SWITCHES

SUBMINIATURE SERIES



TOTALLY ENCLOSED
EXCEEDS MIL-S-6807A

. . . 1" DIAMETER . . .
- 12 POSITIONS — 30° INDEX
- 10 POSITIONS — 36° INDEX
- 8 POSITIONS — 45° INDEX
- 1 TO 16 DECKS
- SINGLE OR MULTI POLE
- ⅜ - 32 SINGLE HOLE MOUNT
- CARRY 10 AMP CONTINUOUS

. . . MAKE & BREAK . . .
5 AMP 115 V.A.C. — 3 AMP 28 V.D.C.

JANCO CORPORATION
3111 WINONA, BURBANK, CALIF.

CIRCLE 668 ON READER SERVICE CARD

catalogs and bulletins.....continued

(I-74) Sub-miniature Connectors—Catalog, 12 pp. Presents electrical and mechanical specifications, dimensions, illustrations. Continental Connector Corp, 34-63 56 St, Woodside 77, NY.

(I-75) Fhp Motors—Catalog, 8 pp. Gives general descriptions of special purpose motors. Includes performance table of standard motors. Franklin Electric Co, Inc, 345 E Spring St, Bluffton, Ind.

(I-76) Terminal Blocks—Catalog, 22 pp. Shows standard terminal blocks rated to 750 v and with up to 60 terminals. Curtis Development & Mfg Co, 3292 N 33 St, Milwaukee 16.

(I-77) Small Limit Switch—Brochure, 4 pp. Switch is smaller than 4 by 1¼ in. Rated at 6 a at 600 vac. Several different types of actuation levers available. R B Denison Mfg Co, 386 Broadway, Bedford, Ohio.

(I-78) Machine Tool Limit Switches—Bulletin, 8 pp. Shows ratings, dimensions, circuits for different functions. Table lists many contact arrangements. Housing is water, dust and oil tight.. R B Denison Mfg Co, 386 Broadway, Bedford, Ohio.

(I-79) Electronic Connectors—Brochure, 6 pp. Shows construction and specifications of miniature, quick disconnect connectors of solder, crimp, hermetic, rack and panel types. The Deutsch Co, Electronic Components Div, Municipal Airport, Banning, Cal.

(I-80) Silicones in Electronics—Brochure, 12 pp. Gives properties and uses of silicones for potting, molding, insulating, cooling and other electronics uses. Dow Corning Corp, Midland, Mich.

(I-81) Heat and Corrosion-resisting Alloys—Catalog, 31 pp. Describes nickel-chromium and iron alloys. Contains formulas for heating element calculations, tables of alloy properties and temperature-resistance charts. Driver-Harris Co, Harrison 19, NJ.

(I-82) Magnetic Clutches—Catalog, 8 pp. Presents dimensions and specifications of miniature magnetic clutches and brakes for instruments or controls systems. Dynamic Instrument Corp, 59 New York Ave, Westbury, NY.

(I-83) Terminals and Connectors—Catalog, 20 pp. Presents temperature ranges and dimensions of solderless types. Also shows hand wiring tool. ETC Inc, 990 E 67 St, Cleveland.

(I-84) Plastic Film Capacitors—Bulletin, 4 pp. Gives dimensions, electrical characteristics of polystyrene and polyester capacitors. Efcon, Inc, Patterson Pl, Roosevelt Fd, Garden City, NY.

continued

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ACCURATE, HIGH SPEED COUNTING by REMOTE CONTROL

ELECTRIC COUNTERS

There's a standard Durant Electric Counter to fit practically any OEM application . . . enabling you to build modern electric counting into your PRODUCT, MACHINE or METHOD.

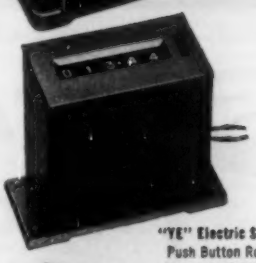
Durant's "HIGH VISIBILITY", with clean-cut legible figures set high up and close to the window, show the exact figure at a glance. Many Durant fully enclosed Electrics have been performing accurately and dependably under varying conditions for years and years — giving the reliability so necessary in a counting operation.

"Y" Electric Series (Model 6-Y-1-MF) 1000 CPM

"CS" Electric Series (larger size — larger figures)

Ideal for PANEL MOUNT (placed and mounted from front) on machine or at control center

Tumbler Lock Key Reset for "tamper control"



"YE" Electric Series Push Button Reset (Model 5-YE-8947-Q) 1500 CPM

"Y" Electric — Small, compact; AC counters equipped with integral rectifier for high speed and long life. Records accurately at high, low, or intermediate speeds.

"CS" Electric — Same external design and features as "Y" Series, but with larger case size and larger figures . . . for more rugged, heavy duty applications.

"YE" Electric — With electric instant reset or finger-flick instant reset.

"Y" Electric Series 4 figure (Model 4-Y-9434-B) 600 CPM

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Durant offers photo-electric, lever, roller arm, star wheel, or limit switch units for use with Electric Counters.

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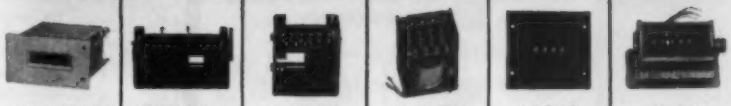
Accurately Count Everything . . . EVERYWHERE



"YE" SERIES HERMETICALLY SEALED FOR MILITARY

MODEL 3-3-5-Y ELECTRIC COUNTERS ONE FRAME

MODEL 6-Y ELECTRIC PREDETERMINING COUNTER

PUSH BUTTON RESET ELECTRIC FOR MILITARY APPLICATION

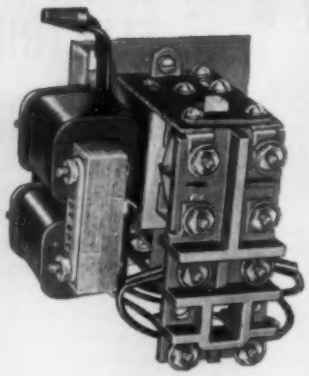
4 FIGURE "Y" ELECTRIC PANEL MOUNT

"SP-MF" ELECTRIC PREDETERMINED COUNTER

REPRESENTATIVES IN ALL PRINCIPAL CITIES

CIRCLE 465 ON READER SERVICE CARD

Floatless, Electrode Type, Liquid Level Controls



2 Pole Level Control

TYPICAL APPLICATIONS

- Pump Controls
- High and Low Level Cutoffs
- High and Low Level Alarms
- Multi-level Signals
- Volumetric Metering
- Boiler Feedwater and Cutoff
- Sewage Ejector Controls
- Carbonator Pump Controls
- Submersible Pump Cutoff
- Evaporator Cutoff
- Process Industries Controls
- Special Panels and Controls

PRINCIPLE OF OPERATION—The operation of controlling liquid levels by means of electrodes is simple, accurate, and positive. A combination of a matched relay and transformer, integrally mounted on a common baseplate and connected to one or more electrodes positioned to contact the liquid surface at predetermined levels, actuates the opening and closing of electrical contacts on the relay. The contacts may be used to switch a motor, motor starter, contactor, motorized valve, solenoid valve, alarm bell, pilot light or any other device.

SALIENT FEATURES—There are no moving parts in the liquid. Installation is easy, requiring no adjustment aside from cutting the electrodes to their proper lengths. Operation is unaffected by acids, alkalis or caustics and is independent of temperature and pressure. The control can be located remote from the liquid container. Levels can be maintained within 1/16 inch. All terminals are located on a single panel on top of the relay for accessibility. All contacts and moving parts are situated below the main panel for maximum protection. Spacing and insulation are adequate for 600 volts. The baseplate is provided with keyhole for mounting screws. Equipment is listed by Underwriters Laboratories.

ELECTRICAL RATINGS—Controls are available with coils suitable for any combination of supply line voltage and frequency. Contacts are U/L rated at 1 HP for 115 or 230 volts, 10 amperes 115 volts or 5 amperes 230 volts inductive load, and 690 volt-amperes 230 volts or 125 volt-amperes 460 volts for pilot duty. All controls are of the double break, bridge type and have wiping action on closure.

CHARLES F. WARRICK COMPANY
1961 W. Eleven-Mile Road
Berkley, Michigan
Telephone JOrdan 4-6667

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Stepping Relays
Delay Relays
Timers
Contactors
Motor Starting Relays
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. . . in any thermosetting plastic material. No tooling cost. Most parts meet military specs. Write for complete catalog.

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1421 South Broadway, Dayton 1, Ohio

CIRCLE 466 ON READER SERVICE CARD
CIRCLE 670 IN READER SERVICE CARD

catalogs and bulletins.....continued

(I-85) Indicator and Pilot Lights—Catalog, 31 pp. Presents circuits, dimensions and specifications for miniature lights used in instruments, aircraft, computers. Eldema Corp, 1805 Belcroft Ave, El Monte, Cal.

(I-86) Large Resistors—Bulletin, 4 pp. Gives construction and ratings of wire-wound resistors, resistor banks. Mullenback Div, Electric Machinery Mfg Co, 2100 E 27 St, Los Angeles 58.

(I-87) Terminals, Connectors—Catalog, 12 pp. Illustrated shapes furnished by reels for cold crimping or welding to wire by machines which are also shown. Electric Terminal Corp, Box 2217, Providence 5, RI.

(I-88) Potentiometers—Brochure and four data sheets, 8 pp. Presents dimensioned drawings and specifications of precision linear and nonlinear types and a low torque precision design. Electro-Mec Laboratory, Inc, 47-51 33 St, LI City, NY.

(I-89) Goniometer—Brochure, 4 pp. Describes instrument for measuring and testing potentiometers, synchros and similar rotary electronic components. Electro-Mec Laboratory, Inc, 47-51 33 St, LI City, NY.

(I-90) Germanium Diodes—Bulletin, 4 pp. Tabulates specifications of general purpose, special purpose and computer indium bonded diodes. Electron Research Inc, Subs of Erie Resistor Corp, 530 W 12 St, Erie, Pa.

(I-91) Electronic Components—Brochure, 4 pp. Illustrates subminiature to 50 in. OD slip ring assemblies; relay switch and precision selector switch. Electro Tec Corp, 10 Romanelli Ave, S Hackensack, NJ.

(I-92) Switches and Actuators—Catalog, 31 pp. Provides illustrations, dimensioned drawings, specifications for heavy duty, subminiature, doublepole, enclosed diecase, one way impulse, hermetic and other types. Includes technical discussion of the subject. Licon Div, Illinois Tool Works, 6606 W Dakin, Chicago.

(I-93) Magnetic Ceramics—Bulletin, 4 pp. Offers kits containing ferrite magnetic cores; voltage dependent, negative temperature coefficient or light dependent resistors; memory cores, planes or stacks. Ferroxcube Corp of America, E Bridge St, Saugerties, NY.

(I-94) Silver-zinc Batteries—Two brochures, 10 pp. Provides performance and design details of primary, automatically activated batteries for one time use; and secondary (rechargeable) batteries. Cook Batteries, Subs of Telecomputing Corp, 2850 Olive St, Denver 7, Col.

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ELECTRIC HEAT
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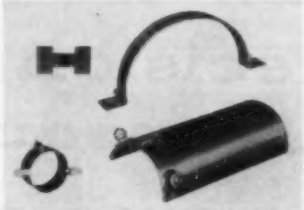
Watlow FIREROD® CARTRIDGE HEATERS

New high in heat concentration . . . longer life . . . new design flexibility. Provides same heat as standard heating unit in 1/5 the size! Standard cartridge heaters also available.



Watlow STRIP HEATERS

Straight or curved design. Widths ¾" and over, lengths to 72". Post, button and bracket type terminals and flexible leads.

Watlow IMMERSION HEATERS

Straight or curved. Diameter ¾" to 2", any length, with capacities to 10,000 watts.

Watlow TUBULAR HEATERS

Available in sheath materials for all purposes . . . various terminals to meet special needs . . . in most voltages . . . in standard as well as odd lengths, diameters and wattages.

Watlow FLEXIBLE SILICONE RUBBER HEATERS

For temperatures up to 450°F., watts densities to 35 watts/sq. in. Any size, any shape, easily mounted.

Watlow NARROW-BANDED HEATERS

Widths 1" to 2", Diameters 1⅜" and up. Watts Densities up to 45 Watt/sq. in. Patented Clamping Band gives excellent heat transfer.

Delivery—Two Weeks or Less

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ELECTRIC MANUFACTURING CO.
1376 Ferguson Avenue
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6024

CIRCLE 467 ON READER SERVICE CARD 467

DISPLACEMENT
Models 580 (top) and 581 (bottom)

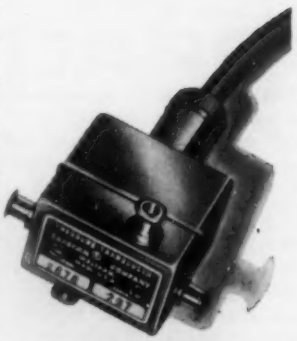
VELOCITY
LVsyn

DISPLACEMENT
Linearsyn

Precision Transducers FROM SANBORN

Linear motion transducers available from Sanborn Company now include the compact, ready-to-use flange-mounted *Model 580* and threaded *581* "probe-styles" for displacements as small as 0.00002" . . . thirty models (shielded and unshielded) of the rugged *Linearsyn* differential transformer for strokes from ±0.005" to ±1.0", displacements as small as 0.000001" . . . and twelve models of the *LVsyn* for producing a DC voltage proportional to a linear velocity. Features of the *580—581* probe-style units include 0.5% linearity; basic sensitivity at 2400 cps of 2.4 volts output/inch displacement/volt excitation; built-in output level adjustment, phase shift and temperature change compensation; carbide-tipped stainless steel contact rod riding in jeweled bearings. Both the *LVsyn* and *Linearsyn* transducers are extremely durable units, immersible in working fluids, introduce little or no friction, and have infinite resolution. Standard Linearsyn coil lengths range from 0.564" to 6.88", LVsyn coil lengths from 3.16" to 22.75".

For differential and single-ended pressure measurements, *Series 267 and 268* transducers for operation in a carrier system offer sensitivities of 40 uv/mm Hg/volt excitation and 40 uv/0.1 mm Hg/volt excitation. Compact, Monel cases have standard Luer connectors.



PRESSURE
Series 267, 268

Contact your local Sanborn Sales-Engineering Representative for bulletins containing complete facts or write the Sanborn Industrial Division in Waltham. Sanborn Sales-Engineering Representatives are located in principal cities throughout the U. S., Canada and foreign countries.

for long stroke, high pressure, high temperature requirements . . .

. . . special-order LVsyn and Linearsyn displacement transducers can be supplied. Strokes up to 20" are possible . . . pressure ratings up to 5000 psi, when transducer is submerged in a high pressure medium . . . operating temperature ranges as wide as −65°F to +450°F. Consult factory, stating your requirements.

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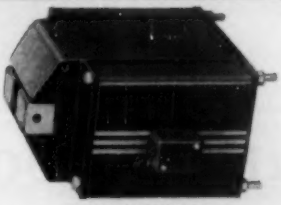
MASTERS OF SOLENOID DESIGN AND APPLICATION

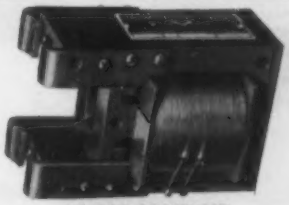
P-128 SOLENOID

P-100 PULL TYPE & Q-100 PUSH TYPE PURE DIRECT CURRENT SOLENOIDS
Pull Rating (85% Voltage): 2 to 2000 lbs.
Stroke: 2" to 9".
Made for all voltages up to 750 volts.



P-334 SOLENOID

P-300 PULL TYPE & Q-300 PUSH TYPE SOLENOIDS
Pull Rating (85% Voltage): 0.75 to 150 lbs. AC—0.75 to 400 lbs. DC.
Stroke: 5/8" to 5".
Made for all frequencies, and for all voltages up to 750 volts — AC and DC.

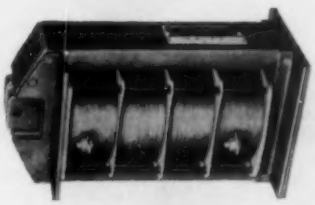


NA-764 SOLENOID

NA-700 SHORT STROKE SOLENOIDS (Interchangeable with National Acme Solenoids)
Pull Rating (85% Voltage): 1 to 300 lbs.
Stroke: 1/2" to 1 1/2".
Made for all frequencies, and for all voltages up to 750 volts — AC and DC.

AS-426 SOLENOID

AS-400 HIGH SPEED SOLENOIDS (Capable of operating at rates as high as 500 operations per minute)
Pull Rating (85% Voltage): 1.5 to 14 lbs.
Stroke: 1 1/2" to 2 1/2".
Made for all frequencies, and for all voltages up to 750 volts — AC and DC.

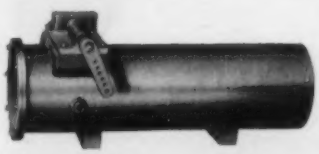


AL-828

AL-800 LONG STROKE SOLENOIDS
Pull Rating (85% Voltage): 1.5 to 25 lbs.
Stroke: 2 1/2" to 4 3/4".
Made for all frequencies, and for all voltages up to 750 volts — AC and DC.

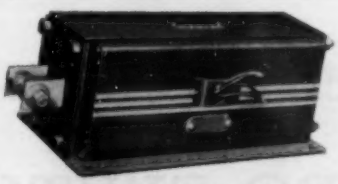
FX-326

FX-300 EXPLOSION PROOF, OIL IMMERSED SOLENOIDS
Pull Rating (85% Voltage): 3.5 to 150 lbs.
Stroke: 1 1/4" to 5".
Made for all frequencies, and for all voltages up to 750 volts — AC and DC.



R3DX-334 SOLENOID OPERATOR

R3DX-300 EXPLOSION PROOF SOLENOID OPERATORS (Reciprocating Solenoids)
Pull Rating (85% Voltage): 3 to 150 lbs.
Stroke: 1 1/4" to 5".
Made for all frequencies, and for all voltages up to 750 volts — AC and DC.

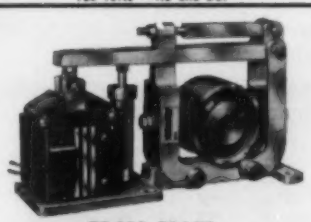


R2D-328 SOLENOID OPERATOR

R2D-300 SOLENOID OPERATORS (Reciprocating Solenoids)
Pull Rating (85% Voltage): 1 to 150 lbs.
Stroke: 1" to 5".
Made for all frequencies, and for all voltages up to 750 volts — AC and DC.

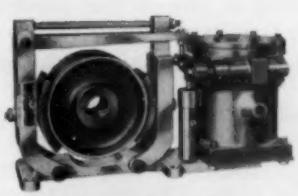
AX-426 RECIPROMOTOR

AX-400 RECIPROMOTORS
Rectilinear induction motors — for operations requiring reciprocating forces of various magnitudes. May be furnished for practically any force and length of stroke.
Made for all frequencies, and for all voltages up to 750 volts — AC.



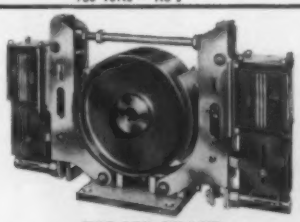
TS-118 BRAKE

TS-100 SOLENOID BRAKES
Torque Rating (85% Voltage): 3 to 2100 ft. lbs.
Wheel Diameters: 2 1/2" to 14".
Made for all frequencies, and for all voltages up to 750 volts—AC and DC. Also available for air operation, and hydraulic operation for any pressure to 2400 p.s.i.



TSX-528 BRAKE

TSX-500 EXPLOSION PROOF AC & DC BRAKES
Torque Rating (85% Voltage): 10 to 2100 ft. lbs.
Wheel Diameters: 3 3/4" to 14".
Made for all frequencies, and for all voltages up to 750 volts — AC and DC.



T2S-150 BRAKE

T2S-100 DOUBLE ACTION SOLENOID BRAKES
Torque Rating (85% Voltage): 1,400 to 75,000 ft. lbs. — Wheel Diameters: 18" to 72".
Made for all frequencies, and for all voltages up to 750 volts—AC and DC. Also available for air operation, and hydraulic operation for any pressure to 2400 p.s.i.

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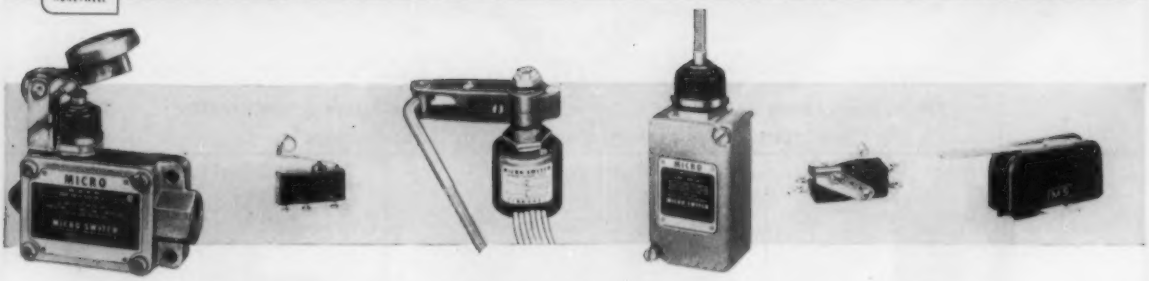
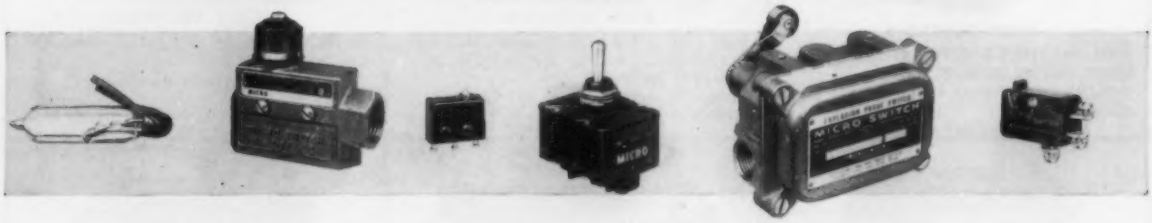
MICRO SWITCH Precision Switches



a few of the 12,000 reasons



why it makes sense to

check switch problems with

MICRO SWITCH

That's right! MICRO SWITCH has designed over 12,000 different precision switch types for specific applications. There obviously are ready answers for most switch problems in this huge MICRO SWITCH line, both for up-dating your present machines and when designing new ones. There's an experienced MICRO SWITCH field engineer near you, ready to help on your switch problems. And, replacement is as easy as calling your nearby MICRO SWITCH distributor. You'll find him in the Yellow Pages. For precision switches, make MICRO SWITCH your first source. Best way to be sure of precise operation, experienced engineering counsel, and production capabilities that mean savings for you.

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cam-7-line

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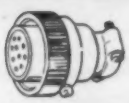
AIRCRAFT AND ELECTRONIC INSTRUMENTATIONS—MS, MS-A, MS-B, MS-E, MS-R SERIES, conforming to Specification MIL-C-5015D. Vibration-proof—Lightweight—Plugs are available with from 1 to 100 contacts. 15 different insert diameters and 260 contact layouts. 6 shell styles, MS 3100 to MS 3108 with all accessories. Environmental-Resisting MS-E and MS-R Series have interfacial sealing at mating faces and integral grommet seal at wire entry plus—grounding lugs and integral cable clamp.

GENERAL CIRCUITRY AND QUICK DISCONNECT—K, RK SERIES, with special acme thread. The all-purpose series with eight insert diameters available. Conduit and cable clamp entry types. 1 to 110 contacts. 10, 15, 30, 40, 60, 80, 115 and 200 amp. silver plated contacts. High quality phenolic, melamine, and formica insulators. Cadmium-plated aluminum alloy shells.

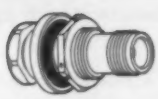
UNIT-PLUG-IN RACK/PANEL-DP, DPB, DPD, DPD2, DPD2R, DPJ, DPS SERIES, available with from 2 to 180 contacts in rectangular inserts. With and without shells; coaxial and high voltage contacts. Permit quick disconnect, interchange, replacement, testing, and inspection of assemblies and sub-assemblies.

AUDIO AND LOW-LEVEL CIRCUITS—P, XLR, XK, O, UA, BRS SERIES, in many shell styles and insert layouts. Straight and 90° angles. Latch-lock types. Wall-mounting, panel, locknut mounting, and adapter receptacles, single and two-gang. 10 and 30 amp. contacts, coaxials.

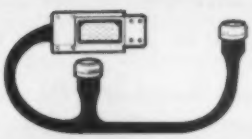
MINIATURE AND SUB-MINIATURE—D, US, DPA, DPX, AND K-MINIATURE SERIES, designed for amplifiers, miniature indicators, computer circuits, telemetering equipment, and general instrumentation of limited space requirements. Variety of shell styles, junction shells, and insert arrangements. Available with from 2 to 50 contacts, plus coaxials.



COAXIAL RF SERIES—available in a wide range of Series and types from sub-miniature to large cable applications. New Cannon adapters available for use with latest cable developments. Cannon's latest RF Plugs include aluminum versions designed for use where weight-saving is a critical design criteria.



GM AND PLUG HARNESS SYSTEMS—Cannon produces a wide range of GM Plugs to fit specific missile applications, ranging from straight umbilical dis-connects to stage-separation dis-connects. Cannon also produces Plug Harness Systems featuring MS or other specified plugs and cables as one unit, available with various contact types and sizes. From 8 to 140 contacts. Highest quality and proven reliability. Varied remote disconnect methods actuated by hydraulic, pneumatic, explosive, or manual means.



The Cannon Electric Company also has available a wide variety of plugs for Battery-Power, Fire-wall, Watertight, Printed Circuit, and other applications, as well as "Kwik-Term" Terminals and DC Solenoids.

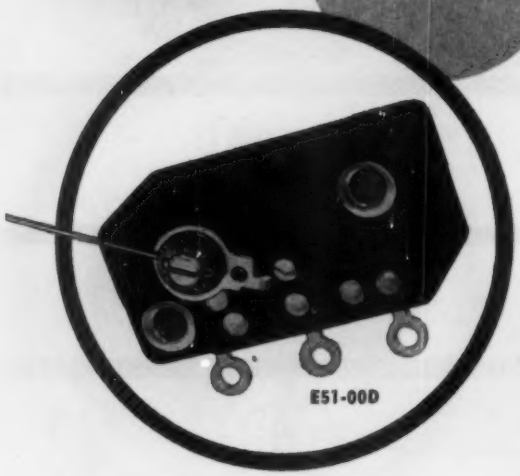
FOR ADDITIONAL INFORMATION on the typical designs illustrated . . . other configurations for your specific applications . . . or the design, engineering and manufacture to your special needs . . . write to Cannon Electric Company—3208 Humboldt Street, Los Angeles 31, California. Please refer to Dept. 506.

LARGEST FACILITY IN THE WORLD FOR PLUG RESEARCH-DEVELOPMENT-MANUFACTURE

CANNON PLUGS

MARCA REG. EN MEXICO

New FEATHER TOUCH SNAP ACTION COIN SWITCH



- Feather touch operating torque (4 inch-grams max.)
- Friction-free blade pivot
- Lateral rock-wipe contact action
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- Rated: UL 5 amps/250 V a-c

Extremely low operating force and precise tolerances provide positive electrical control for pressure indicators, sensing timers or relays, office machines and vending machines. Operating force can be varied by length of actuator wire.

Your switching problems may find solution from over 8,000 Cherry switch variations. Write for complete literature today!

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ECONOMICAL **POWER RESISTORS** FOR FLIGHT USE

Light-weight, tough, flexible. Operate under high pneumatic pressure. Resist corrosion. Immersible. Insulated with silicone rubber or neoprene. Meet USAF specifications.

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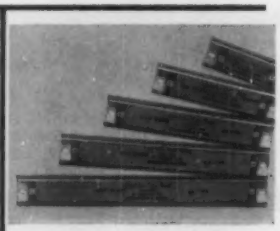

New lightweight, space-saving resistors permit substantial efficiencies and economies in aircraft and missile electronic apparatus. Units are mounted in direct contact with inner surface of chassis or case so that 25% to 40% of heat generated is emitted to atmosphere. Derating curves are available.

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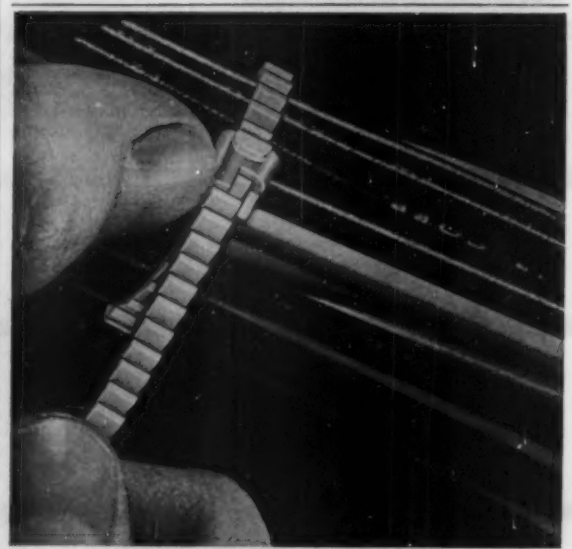

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catalogs and bulletins.....continued

(I-95) Insulated Electronic Components—Catalog, 12 pp. Gives dimensions, voltage ratings, materials for standoff terminals, connectors, terminal boards and others. Garde Mfg Co, 53 John St, Cumberland, RI.

(I-96) Aluminum Sheathed Telephone Cable—Catalog, 40 pp. Shows construction, installation and maintenance of cable for underground, overhead and corrosive atmospheres. General Cable Corp, 730 Third Ave, NYC 17.

(I-97) Jacks and Plugs—Brochure, 22 pp. Describes communications, test, control equipment jacks, plugs, panels, cords, indicating lamps. Stromberg-Carlson Div of General Dynamics Corp, 100 Carlson Rd, Rochester, NY.

(I-98) Key Switches—Brochure, 26 pp. Describes key and pushbutton switches, mountings and accessories. Designed for low current circuits. Stromberg-Carlson Div of General Dynamics Corp, 100 Carlson Rd, Rochester, NY.

(I-99) Stepping Switches—Brochure, 10 pp. Explains operation of a 10 point and a 100 point switch. Uses four-wire switch. Stromberg-Carlson Div of General Dynamics Corp, 100 Carlson Rd, Rochester, NY.

(I-100) Dc Generators—Bulletin, 6 pp. Contains dimensions, ratings, construction for units from one to 150 kw. General Electric Co, Dc Motor & Generator Dept, 3001 E Lake Rd, Erie 1, Pa.

(I-101) Selenium Rectifiers—Bulletin, 8 pp. Tabulates data on miniature and subminiature rectifiers and diodes including special types for printed wiring boards. Radio Receptor Co, Inc, Subs of Gen Instrument Corp, 240 Wythe Ave, Brooklyn 11, NY.

(I-102) Ceramic Permanent Magnets—Bulletin, 8 pp. Presents descriptions, formulas, graphs, tables of properties; tables of dimensions and chart of possible applications. Indiana Steel Products, Div of Indiana General Corp, 405 Elm St, Valparaiso, Ind.

(I-103) Semiconductor Diodes and Rectifiers—Catalog, 16 pp. Provides electrical characteristics, dimensions of silicon and selenium diodes, rectifiers, contact protectors, zener diode voltage regulators. International Rectifier Corp, 233 Kansas St, El Segundo, Cal.

(I-104) Nickel-cadmium Batteries—Brochure, 50 pp. Presents physical and electrical data on sintered plate, and pocket plate batteries used as stand-by power sources. Nicad Div, Gould-National Batteries, Inc, Pleasant St, Easthampton, Mass.

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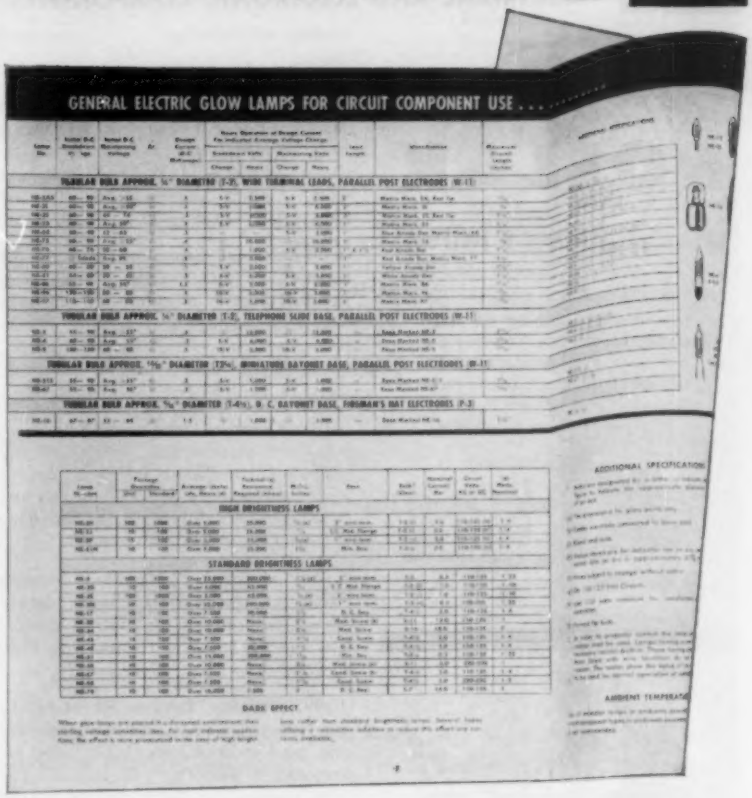

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Contains all the information you'll need to help you choose the right glow lamp for the job. Gives complete specs on G-E Glow Lamps for circuit component and for indicator use. Packs more data in fewer pages than any other brochure . . . recommends specific lamps for specific circuits . . . covers physical and electrical characteristics. All this and much, much more. Send for your free copy of Bulletin No. 3-0193 today. The right number for you to circle is shown below. General Electric Co., Miniature Lamp Dept. M-031, Nela Park, Cleveland 12, Ohio.

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Size: 25/32"x1 1/32"x 1 3/16"

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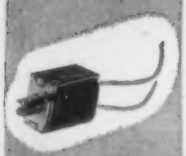

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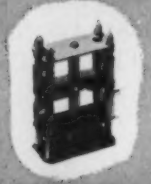

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catalogs and bulletins.....continued

(I-105) **Batteries**—Four bulletins, 19 pp. Shows construction, physical and electrical characteristics of alkaline batteries ranging from industrial to miniature sizes. Includes self-contained, automatic dc power units. Gulton Industries, Inc, Alkaline Battery Div, 2 Gregg St, Lodi, NJ.

(I-106) **Ceramic Capacitors, Resistors**—Six bulletins, 23 pp. Presents characteristics and dimensions of miniature and subminiature capacitors with various special properties. Also temperature sensitive resistors. Glenco Corp, Subs of Gulton Industries, Inc, 212 Durham Ave, Metuchen, NJ.

(I-107) **Ceramic Transducers**—Bulletin, 8 pp. Gives characteristics, dimensions and shapes of transducers for such uses as sonar, earphones, accelerometers. Gulton Industries, Inc, Materials & Ceramics Div, 212 Durham Ave, Metuchen, NJ.

(I-108) **Magnetically Actuated Mercury Switches**—Catalog, 4 pp. Shows dimensions, ratings and ways to utilize. Also dry reed and tilt switches. Hamlin, Inc, Lake & Grove Sts, Lake Mills, Wisc.

(I-109) **Stepping Devices**—Brochure, 12 pp. Presents specifications and sample circuits used in driving printed circuits, potentiometers and other components. The A W Haydon Co, 244 N Elm St, Waterbury, Conn.

(I-110) **Timers**—Catalog, 38 pp. Describes timing motors; electronic and electro-mechanical timing devices; and time indicating instruments. The A W Haydon Co, 244 N Elm St, Waterbury, Conn.

(I-111) **Circuit Breakers**—Bulletin, 12 pp. Provides ratings, dimensions, terminal styles for ac and dc hydraulically delayed breakers. Heinemann Electric Co, 713 Plum St, Trenton, NJ.

(I-112) **Relays**—Catalog, 18 pp. Describes electronic subminiature, microminiature and time-delayed balanced rotary types. Hi-G, Inc, Bradley Fd, Windsor Locks, Conn.

(I-113) **Solid State Electronics**—Catalog, 16 pp. Outlines specifications for several typical products such as time delay relay, and furnishes one example of complete general specifications. Hydro-Aire Co, 3000 Winona, Burbank, Cal.

(I-114) **Frequency Standards**—Brochure, 4 pp. Furnishes specifications for transistorized miniature standards using aircraft power source. Gibbs Mfg & Research Corp, 450 N Main St, Janesville, Wisc.

(I-115) **Terminals** – Catalog, 24 pp. Sketches and tables give dimensions of locking and plain terminals. Shakeproof Div of Ill Tool Works, St. Charles Rd, Elgin, Ill.

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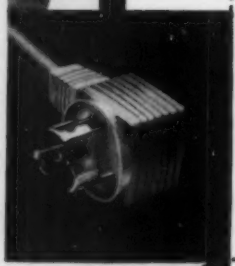
Just a few examples . . .

FINGER-PULL plug
Takes the strain off the wire — and adds a smart useful look to any electrical product — available in a variety of sizes and designs, Patented.



LOCKING plug molded-on to wire
Seal rim — an integral part of the plastic form — keeps out foreign matter and moisture.

Heavy duty STRAIN RELIEF
Designed for use on portable tools, appliances, etc. Our mold set-ups are flexible, permitting infinite variety of nose section shapes and dimensions.

CORD ASSEMBLY
All parts designed for special customer need. Plugs, color matching extra flexible wire, and creel provide minimum size overall for small space containment.

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Representatives in key cities

catalogs and bulletins.....continued

(I-116) **Electrical Connections**—Catalog, 98 pp. Describes molds for making on-the-spot heavy electrical connection by thermit principle. Erico Products, Inc, 2070 E 61 Pl, Cleveland.

(I-117) **Electrical Cord Reels**—Catalog, 30 pp. Describes portable, stationary and power driven cord and cable reels. Also swivel units and collector rings. Industrial Electric Works, Inc, 1509 Chicago St, Omaha, Neb.

(I-118) **Rectifiers**—Bulletin, 4 pp. Describes selenium rectifiers that use no artificial barrier layer. Radio Receptor Co, Inc, Subs of Gen Instrument Corp 240 Wythe Ave, Brooklyn 11, NY.

(I-119) **Semiconductors**—Catalog, 104 pp. Presents electrical characteristics, ratings, dimensions, applications of silicon and selenium diodes and rectifiers. International Rectifier Corp, 233 Kansas St, El Segundo, Cal.

(I-120) **Antenna Insulators**—Bulletin, 4 pp. Gives strengths and dimensions of suspension and strain insulators. Isolantite Mfg Corp, 339 Warren Ave, Stirling, NJ.

(I-121) **Electronics Hardware**—Catalog, 8 pp. Describes couplings, drives, magnetic shields, bezel assemblies and other components. Jan Hardware Mfg Co, Inc, 38-01 Queens Blvd, Long Is City, NY.

(I-122) **Pendant Switches**—Bulletin, 8 pp. Describes rubber encased multibutton or toggle switches. Includes models molded to cable. Joy Mfg Co, Electrical Products Div, 1201 Macklind Ave, St. Louis 10.

(I-23) **Ac Generators**—Brochure, 15 pp. Outlines characteristics of brushless generators, controls and motor generators. Capacities to 500 kva. Kato Engineering Co, 1415 First Ave, Kato, Minn.

(I-124) **Power Supplies**—Catalog, 24 pp. Provides specifications of vacuum tube, transistorized, magnetic and hybrid voltage regulated supplies. Kepco, Inc, 131-38 Sanford Ave, Flushing 55, NY.

(I-125) **Terminal Blocks**—Catalog, 20 pp. Provides specifications, dimensional drawings of terminal blocks, electronics switches, marine lamp sockets, outlets. Kulka Electric Corp, 633 S Fulton Ave, Mount Vernon, NY.

(I-126) **Transfer Switch**—Bulletin, 4 pp. Describes automatic type with ratings to 800 amp, 600 v. Lake Shore Electric Co, 205 Willis St, Bedford, Ohio.

(I-127) **Wiring Devices**—Catalog, 100 pp. Gives ratings and dimensions of switches, outlets, lamp holders, fixtures and wall plates. Pass & Seymour, Inc, Syracuse 9, NY.

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Just 1 size for 2 #18, 2 or 3 #16, 2 #14, 1 #12 with 1 #14 — or equivalent combinations.

Tough see-thru Nylon. High insulating value. Easy inspection.

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Just 1 size — Hand or Pneumatic. Fast acting — no adjustments — no wire twisting — load either side — splice caps self-positioning.

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UL & CSA approved — 600 V. max. bldg. wire; 1000 V. max. in fixtures — to 105°C. Also UL approved for 1000 V. max. in electric signs.

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New circular readout controller designed specifically for use with packaging and plastics machinery. Note the improved indicator visibility.

Always a true indication of temperature. Readout and control never limited by mechanical stops or machinery vibration.

Positive readout with guaranteed independent control—meter movement completely separate!

Circular readout available on proportioning and on-off units. All units are designed to fit standard mounting dimensions.

The first compact servo indicating temperature control with circular readout offering high accuracy at low cost.

For additional information on complete range of controls, costs, etc., write or phone:

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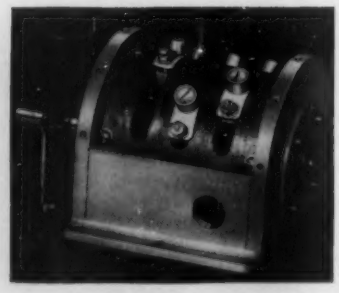
ROTARY SWITCH by SUPERIOR

Adapted to many types of Cycling Equipment in which prime requisites are safety, reliability and LONG LIFE.



Broad applicability. Flexible basic design is adapted to existing cycling equipment as well as many O.E.M. applications. The switch shuts off power at the end of each cycle and automatically starts the cycle unless interrupted. Safety is a bonus feature with a new high attained in dependable, long ring life.

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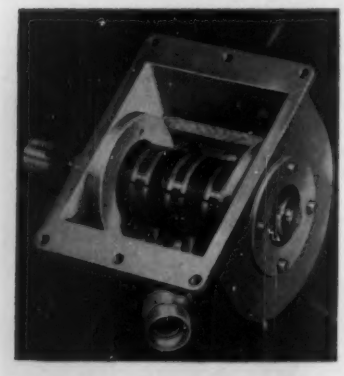

Superior's wealth of experience in powder metallurgy insures the right selection of brush, ring and insulation materials to fit your specifications. Arcing and subsequent material breakdown are definitely retarded. Photo above shows rings after having operated 2,000,000 cycles.

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SLIP RING ASSEMBLIES
BRUSH HOLDER ASSEMBLIES
BRUSH CONTACTS
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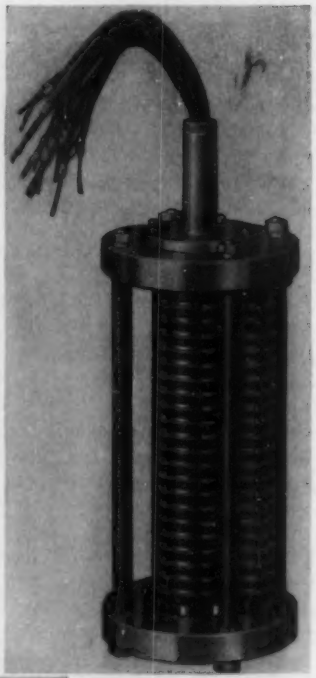
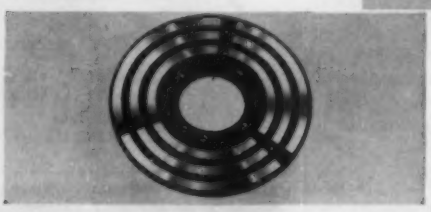
- ***DESIGNED BY SUPERIOR FOR YOUR APPLICATION***
- ***BUILT TO YOUR SPECIFICATIONS***

A long, close acquaintance with this field enables the Superior staff to offer slip ring assemblies and components individually designed for all applications, such as:

SIGNAL CIRCUITS
POWER CIRCUITS
SEGMENTED COMMUTATORS
SPECIAL BRUSH BLOCKS
COMBINATION SIGNAL AND POWER CIRCUITS



Basic drum-type assembly with 24 rings.



Basic pancake-type assembly with segmented rings.

Brush block assemblies, cantilever type.

Space, insulation, noise requirements, and contact composition, and other problems have received our special attention. Superior makes brush contacts, brush holders, rings, all the components — *in one package.*

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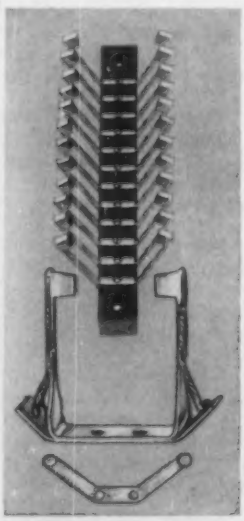
Brush holders can be designed around existing ring assemblies. Even brushes alone can be supplied to fulfill a specific customer need. The brush is the vital link in the entire assembly. Our experience in this area alone has developed a range of brush grades which will withstand any conditions and give optimum operation. We specialize in pilot runs.



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BRUSHES • CONTACTS • SLIP RING ASSEMBLIES
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America's first rocket engine with a launching thrust of 1.5 million pounds is now being developed by Rocketdyne, a division of North American Aviation, Inc.

One of the most critical factors in the successful firing of a rocket or missile is the exact determination of weight and thrust. Present operational rocket engines are tested for weight and thrust by using a series of load cells of no more than 100,000 pounds capacity each, along with allied instrumentation for computing data from the several sources.

Now the BLH development of a single functional cell with a 1.5 million lb. capacity will permit evaluation of total weight and thrust from one source, reducing the number of possible sources of error. Calibration and testing by the National Bureau of Standards has proved the load cell and its instrument system to be accurate to ±0.10% of reading over the full scale from one-tenth to full capacity. The complete system will become part of Rocketdyne's high-thrust test area at Edwards Air Force Base, Calif.

BLH experience and capabilities in force and strain measurement are available for your use, whether in pioneering efforts such as this one, or in the improvement of existing measurement applications. Write for additional proof of BLH capabilities . . . or contact your nearby BLH sales engineering representative for application engineering service.

World's largest single column load cell weighs 2200 pounds, is 44 in. high, 20 in. in diameter.

The huge load cell is performance tested during its development at the BLH plant.

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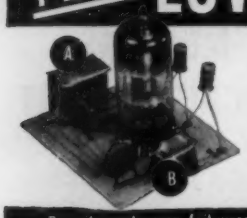

Thin Versatile Co-Netic and Netic Magnetic Shielding Foils

Permit positioning foil-wrapped components A & B closely, minimizing interaction due to magnetic fields . . . making possible compact and less costly systems.

How thin Co-Netic and Netic foils lower your magnetic shielding costs:

1) Weight reduction. Less shielding material is used because foils (a) are only .004" thick and (b) cut and contour easily.

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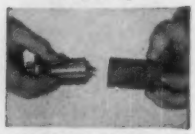
These foils are non-shock sensitive, non-retentive, require no periodic annealing. When grounded, they effectively shield electrostatic and magnetic fields over a wide range of intensities. Both foils available from stock in any desired length in various widths.

Co-Netic and Netic foils are successfully solving many types of electronic circuitry magnetic shielding problems for commercial, military and laboratory applications. These foils can be your short cut in solving magnetic problems.

Cuts readily to any shape with ordinary scissors.

Wraps easily.


Inserts readily to convert existing non-shielding enclosures.

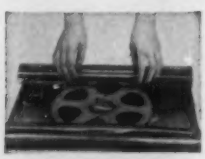
Shielding cables reduces magnetic radiation or pickup.

Wrapping tubes prevents outside magnetic interference.

PROTECT VITAL MAGNETIC TAPES

When accidentally exposed to unpredictable magnetic fields, presto!—your valuable data is combined with confusing signals or even erased.

For complete, distortion-free protection of valuable magnetic tapes during transportation or storage. Single or multiple reel Rigid Netic Enclosures available in many convenient sizes and shapes.


Thin pliable foil wraps easily around magnetic tape, maintaining original recorded fidelity.

Rigid Netic (.014" and up in thickness) Shielded Rooms and Enclosures for safe, distortion-free storage of large quantities of recorded magnetic tapes.

Composite photo demonstrating that magnetic shielding qualities of Rigid Netic Alloy Material are not significantly affected by vibration, shock (including dropping or bumping) etc. Netic is non-retentive, requires no periodic annealing.

Write for further details today.

MAGNETIC SHIELD DIVISION PERFECTION MICA CO.
1322 No. Elston Avenue, Chicago 22, Illinois
ORIGINATORS OF PERMANENTLY EFFECTIVE NETIC CO-NETIC MAGNETIC SHIELDING

478 CIRCLE 478 ON READER SERVICE CARD

Yours for the asking

This "Diamond H" Checklist of Reliable Controls

. . . Relays, Thermostats, Switches . . . engineered to meet your specific requirements in a wide variety of applications including air conditioning, appliances, aircraft, missiles, machine tools, panel boards, heater and motor control circuits, and many others.

• • •

Ask also for our new application data sheets on Series R and Series W Relays, and Rotary Switches.

THE HART MANUFACTURING COMPANY
273 Bartholomew Ave., Hartford 1, Conn.
Phone JAckson 5-3491

CIRCLE 675 ON READER SERVICE CARD

SPEED DETECTOR BREAKTHRU

SPEEDS OF LESS THAN 50 R.P.M. CAN NOW BE ACCURATELY DETECTED WITH NEW DIFFERENTIAL DEVICE DEVELOPED BY

TORQ

. . . detects 1 to 4 different speeds (high and low limits, or single limit on each circuit). Designed for low speed applications of less than 100 rpm. Inquire about SYNPROTEX DIFFERENTIAL unit for low speeds . . . or standard SYNPROTEX speed detectors for speeds from 100 to more than 15,000 rpm.

TORQ
ENGINEERED PRODUCTS, INC.
60 W. Monroe Street • Bedford, Ohio
Phone: BE 2-4100

78

catalogs and bulletins.....continued

(I-128) Balanced Armature Relays—Catalog, 14 pp. Provides dimensions, specifications of relays designed for extreme environmental conditions of missile and electronics applications. Leach Corp, Leach Relay Div, 5915 Avalon Blvd, Los Angeles 3.

(I-129) Crystal Can Relays—Bulletin, 4 pp. Describes subminiature, hermetically sealed relays to meet extreme environmental requirements. Leach Corp, Leach Relay Div, 5915 Avalon Blvd, Los Angeles 3.

(I-130) Power Contactors—Bulletin, 4 pp. Describes rotary, balanced armature relay for extreme environments. Leach Corp, Leach Relay Div, 5915 Avalon Blvd, Los Angeles 3.

(I-131) Footswitches—Catalog, 8 pp. Gives ratings of explosion proof, water tight, dc, other models for light to heavy duty. Linemaster Switch Corp, Woodstock, Conn.

(I-132) Electronics Transformers—Bulletin, 4 pp. Illustrates several models of high power pulse transformers and tabulates specifications. Lockheed Electronics Co, Stavid Div, Rte 22, Plainfield, NJ.

(I-133) Fuses—Bulletin, 8 pp. Furnishes characteristics curves for current limiting fuses with high interrupting capacity and long time lag. Bussmann Mfg Div, McGraw-Edison Co, University at Jefferson, St. Louis 8.

(I-134) Nickel-iron Batteries—Bulletin, 8 pp. Explains theory of operation, construction, uses. Also table of electrical data, weights and dimensions of different models. Thomas A Edison Industries, McGraw-Edison Co, Storage Battery Div. W Orange, NJ.

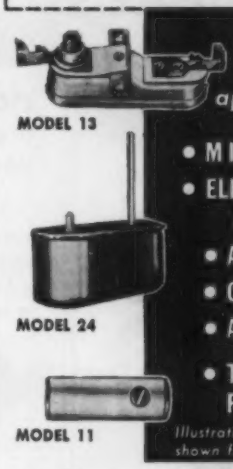
(I-135) Capacitors—Catalog, 16 pp. Presents specifications, dimensions and temperature characteristics of subminiature capacitors designed for extreme conditions and high reliability. Electron Products, Div of Marshall Industries, 430 N Halstead St, Pasadena, Cal.

(I-136) Coaxial Connectors—Catalog, 5 pp. Presents dimensional standards, environmental characteristics of snap-lock and friction-held microminiature connectors. Electro-Physics Laboratories, Div of Marshall Industries, 1900 Walker Ave, Monrovia, Cal.

(I-137) Resistors and Rheostats—Catalog, 20 pp. Contains illustrations and data on wire-wound designs such as dust proof, caged, taper wound, printed circuit and terminal types and others. Tru-ohm Products Div, Model Engineering & Mfg, Inc, 2800 N Milwaukee Ave, Chicago 18.

continued

Rugged, Precision
MINIATURE
THERMOSTATS



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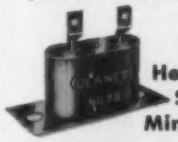
• MISSILES
• ELECTRONIC CONTROL
• AIRCRAFT
• COMPUTERS
• AUTOPILOTS
• TRANSISTOR PROTECTION

Illustrations shown full size

★ Hermetically Sealed
★ Strain Relief Protected

The quality of Ulanet miniature thermostats has been proved by years of dependable operation under the most extreme conditions. Their inherent accuracy and rapid response has been the leading reason for their final choice in so many critical applications. Get in touch with Ulanet for the answer to your heat control problems.



NEW!
Hermetically Sealed
Surface-Sensing
Miniature Thermostat

The only unit that meets the most stringent aircraft and military applications.

Send for Bulletin 100 for full details and dimensional drawings.

FM Series—The only metal thermostats that withstand mechanical clamping or pinching of cartridge without affecting set calibration.

Write for Technical Data Sheets

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ULANET
ELECTRIC HEAT CONTROL ENGINEERS

GEORGE ULANET COMPANY
424 Market St., Newark, N. J.

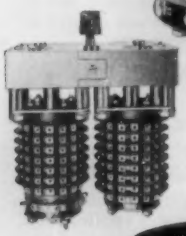
Need SPECIAL ROTARY SWITCHES? see ESCO of WEYMOUTH

TYPE JR

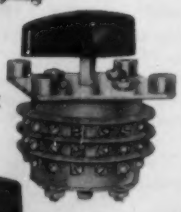
TYPE P

gear-operated TYPE JR

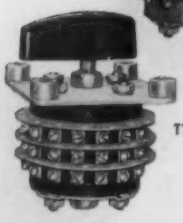
TYPE A/AF



geared pair TYPE HT



TYPE JK



TYPE HT

ESCO standard components are assembled to meet your requirements.

A deviation from one of our standard switch assemblies will give you a *special switch* at a standard-switch cost.

Over 90% of our production is *special* in one way or another.

These standard switches can be modified to fit your application:

- *Type A* — up to 8 positions, 7 sections maximum, detent mechanism, rating 5 amp. 125 volts a-c/30 volts d-c.
- *Type AF* — up to 8 positions, 6 sections maximum, detent action, rating with resistive load 5 amp. at 28 volts d-c or 115 volts 400 cps, per MIL-S-6807.
- *Type P* — Multi-section, up to 4 positions, snap-action, rating 10 amp. 125 volts a-c, 5 amp. 125 volts d-c, 30, 60, 100, 200 amp. 500 volts a-c, or 250 volts d-c. Can be assembled to meet Specification MIL-S-15291.
- *Type JR* — up to 8 positions, 30 sections maximum, detent action, rating 10 amp. 125 volts a-c, 5 amp. 125 volts d-c.
- *Type JK* — 16 pos., 10 sec. max.; detent action; 5 a. 125 v. a-c. Mfg to BuShips 815-1853013 and MIL-S-21604.
- *Type HT* — up to 16 positions, 10 sections maximum, detent action, rating 5 amp. 125 volts a-c.
- *Geared-Pair Type HT* — up to 16 positions, 20 sections maximum, detent action, rating 5 amp. 125 volts a-c. A single knob controls two Type HT switches assembled with a gear mechanism.
- *Navy Switches* — to MIL-S-15291 and Bureau of Ships drawings 9000-S6202-73075, 73826, 73827, 73295, 74422, and others.

Write for data sheets on individual switches or complete new catalog on ESCO rotary multipole switches. Send us your requirements and we'll give you full specifications on the ESCO switch that meets *your* need.

ESCO of WEYMOUTH
ELECTRO SWITCH CORP.
Weymouth (Boston 88), Massachusetts

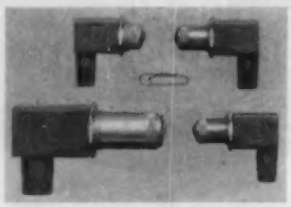
480 CIRCLE 480 ON READER SERVICE CARD

Automation Components

MINIATURE PHOTOELECTRIC SCANNER

Proximity sensor Type SA-1R contains light-source, photocell, and an infrared filter, all in a small anodized-aluminum housing with standard four-prong connector. The solid-state photocell is sensitive, sturdy, and sealed for protection against moisture, dust, or corrosive atmospheres. This scanner operates on reflected light, is responsive to metallic and non-metallic objects. Two models available. Write for Bulletin 260-A.

Type	Max. Sensing	Lamp rating
SA-1R	up to 2 inches	5 v. a-c 60,000 hrs.
SA-1RM	up to 6 inches	2 v. a-c 5,000 hrs.



Short-range scanner SA-1 and medium-range scanner SA-1M consist of two units, the light source and the photocell unit. These small-size scanners have adjustable focus of light-beam for high-precision scanning of rapidly moving parts, with beam-interruption by $\frac{1}{32}$" objects. Eyeshade and infrared filter available to increase range and effectiveness. Write for Bulletin 659.

Type	Max. Sensing	Lamp rating
SA-1	up to 4 feet*)	6 v. a-c 5,000 hrs.
SA-1M	up to 12 feet*)	5 v. a-c 5,000 hrs.

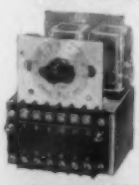
*) can be increased 50% by using eyeshade and infrared filter.

PHOTOELECTRIC RELAYS

Type PE3 — General-purpose relay
Type PE4 — High-speed-impulse relay
Type PE5 — Time-delay relay
Type PE7 — Photo-electric timer

For use with photoelectric scanners; provide suitable light-source voltages; DPDT load contacts handle 8 amperes (non-inductive) at 115 volts a-c.

CK ELECTRONIC TIMERS



Model 120 General-Purpose timer features cold-cathode tube and identical plastic-enclosed plug-in relays, has seven basic modes of operation, including repeat-cycle timing. (Size 4⅞" x 3¾" x 3½".) For information on timers write for Bulletin 120.

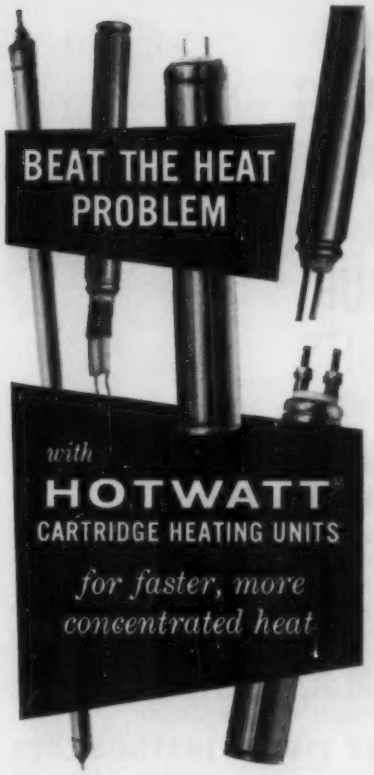
SYNCHRONOUS CONTACTORS

Rotating camshaft actuates distributor-type switches. Single and double-circuit models available. Write for Bulletin "Rototimer".

Whatever your problem in Automation Components, FARMER can help you.

FARMER ELECTRIC
Products Company, Incorporated
2300 WASHINGTON ST. NEWTON LOWER FALLS, MASS.

CIRCLE 677 ON READER SERVICE CARD

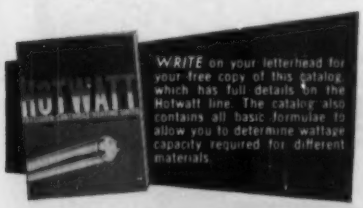


Next time you require intense yet localized heat in any of your equipment, specify Hotwatt cartridge heating units. Hotwatt cartridges come in a wide range of standard and special types and sizes to give you heat where you need it — in a hurry.

And, as an added bonus, Hotwatt's unique manufacturing process assures faster deliveries to your plant. Hotwatt has in-stock all the necessary materials to process your orders quickly.

Hotwatt cartridges are designed for long, trouble-free service. Standard units feature precision-made stainless-steel sheaths; maximum surface temperatures to 1250°F.; etched, not stamped, designations to preserve accurate shape; moisture resistance; maximum heat transfer and minimum core temperature; heating element supported on superior ceramic and solidly packed with magnesium oxide.

Discover for yourself what so many other companies have found out: Hotwatt units are your best buy in cartridge heaters.


HOTWATT
WRITE on your letterhead for your free copy of this catalog which has full details on the Hotwatt line. The catalog also contains all basic formulae to allow you to determine wattage capacity required for different materials.

HOTWATT, INC.

75 MAPLE ST., DANVERS, MASS.

ELECTRIC HEATING SPECIALIST

CIRCLE 678 ON READER SERVICE CARD

catalogs and bulletins.....continued

(I-138) Indicator Lights—Catalog, 16 pp. Gives dimensions and circuits for 44 word indicator lights. Master Specialties Co, 956 E 108 St, Los Angeles 59.

(I-139) Transistor Coolers—Bulletin, 8 pp. Contains curves and sample calculations for choosing cooler on which circuitry is mounted. Modine Mfg Co, 1612 Dekoven, Racine, Wisc.

(I-140) Small Gearmotors—Bulletin, 5 pp. Provides dimensions, torque curves for slow speed output motors suitable for displays, vending machines. Motoresearch Co, Racine, Wisc.

(I-141) Electrical Clips—Catalog, 8 pp. Presents test clips in sizes ranging from miniature to 300 amp capacity. Mueller Electric Co, 1553W E 31 St, Cleveland 14.

(I-142) Miniature Tube Sockets—Catalog, 4 pp. Provides dimensions and specifications of molded glass-bonded mica and ceramoplastics sockets. Mycalex Corp of America, 125 Clifton Blvd, Clifton, NJ.

(I-143) Commutation Switches—Catalog, 8 pp. Describes motor driven commutation switch for applications such as computers, telemetering. Mycalex Corp of America, 125 Clifton Blvd, Clifton, NJ.

(I-144) Insulators—Catalog, 26 pp. Provides electrical and mechanical characteristics and applications of high temperature, high frequency insulators. Mycalex Corp of America, 125 Clifton Blvd, Clifton, NJ.

(I-145) Semiconductors—Data sheets, 22 pp. Gives ratings and specifications of silicon rectifiers and regulators for use in power supplies, magnetic amplifiers and for circuit protection. North American Electronics, Inc, 71 Linden St, W Lynn, Mass.

(I-146) Pulse Transformers—Catalog, 26 pp. Presents theory, application guide, suggested circuits, and testing procedure. Pulse Engineering, Inc, 560 Robert Ave, Santa Clara, Cal.

(I-147) Insulated Wire—Catalog, 44 pp. Presents dimensioned drawings, specifications for insulated wire, cable, cord sets, harnesses, molded parts. Phalo Plastics Corp, 530 Boston Tpk, Shrewsbury, Mass.

(I-148) Carbon Brushes—Catalog, 52 pp. Discusses brush design and maintenance; materials characteristics. Lists carbon grades and applications. The Ohio Carbon Co, 12508 Berea Rd, Cleveland 11.

(I-149) Magnetic Multiplier—Brochure, 4 pp. Shows characteristics and circuit applications of device combining a magnetic circuit and Hall-effect generator. Ohio Semiconductors, Inc, 1205 Chesapeake Ave, Columbus 12, Ohio.

continued

CIRCLE 481 ON READER SERVICE CARD→

WET OR DRY
Resistance is high

. . . with LUNDEY miniature hermetic terminals!

TESTS PROVE—Lundey series #199 miniature hermetic terminals give excellent performance under conditions of high humidity.

In an average test the following results were tabulated:

Relative Humidity	Temp.	Insulation Resistance
90%	80°F	1,000,000 megohms
50%	80°F	3,000,000 megohms

OTHER FEATURES

- Mounting in simple drilled or punched holes . . . no extrusion needed.
- Effective spring loading
- Teflon external member
- Silicone or neoprene core
- Minimum mounting — 15/64" on centers
- Voltage rating — 500V RMS operating
- Current rating — 8 amperes
- Three electrode styles available
- Production-proved
- Meets MIL-T-27 specifications

If humidity creates a problem for you, let Lundey terminals help you solve it. Write for Bulletin #199, Dept. E.

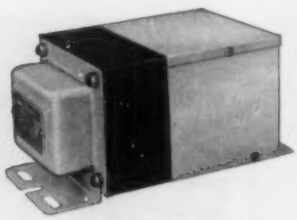
LUNDEY ASSOCIATES

694 Main Street, Waltham 54, Mass.

WHICH CONSTANT VOLTAGE STABILIZER MEETS YOUR NEED?

This compact stabilizer design occupies a minimum of space and is especially adaptable as a component in electronic devices where output voltages must be maintained ±1% of normal. Available in ratings of 15, 25, 50 VA.

Input voltage: 95/130
Output voltage: 120; 6.3



For applications requiring steady-state voltage for laboratory use or electronic circuitry this heavy duty design is available in the following stock ratings and voltage ranges.

Capacities: 100; 200; 300; 500 VA
Input voltage: 95/130; 190/260; 190/260
Output voltage: 120 120 240

This unit has been designed to provide instantaneous response to voltage fluctuation in large loads. Voltage output regulation between no load and full load is constant regardless of input voltage. Current limiting protection under overload conditions.

Available in ratings of 1000 and 2000 VA
Input voltage: 95/130; 190/260; 190/260
Output voltage: 120; 120; 240

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482 CIRCLE 482 ON READER SERVICE CARD

DESIGN TIMING RELIABILITY INTO YOUR CIRCUITS *specify...*

NEW MINIATURE AGASTAT®

time/delay/relays

- ***Recycling* virtually instantaneous—less than .020 seconds**
- **Unaffected by Voltage fluctuations (from 18 to 32 volts DC)**
- **Repeat Accuracy ±5%**

This new AGASTAT meets the environmental requirements of MIL-E-5272A. Built to withstand the rugged conditions of missile and aircraft applications. Lightweight—less than 15 ounces. Space saving—4⅝" tall . . . 1 13/16" wide . . . 1½" deep. Adjustable, with time delays from .030 to 120 seconds. Choice of operation for energizing or de-energizing. For complete specifications, write Dept. A37-637.

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ELASTIC STOP NUT CORPORATION OF AMERICA
1027 NEWARK AVENUE, ELIZABETH 3, NEW JERSEY

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THERMOCOUPLES

THAT WILL WITHSTAND 3000°F AND UP TO 50,000 PSI

LONG LIFE

Sheath Diameters, .04 to .032
Thermocouple Lengths to 100 feet

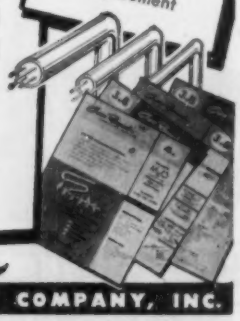
Complete Thermocouples made to every requirement

NEW, SIMPLE CONSTRUCTION

A metallic sheath compressed over ceramic insulated wire. Sheath can be bent and weldments can be performed without loss of insulation.

Write for new Bulletins

3.8A for complete thermocouples.
4 for AEROPAK Ceramic Insulated wire.



Aero Research
INSTRUMENT COMPANY, INC.

DEPT. P.E.D., 315 NORTH ABERDEEN ST. • CHICAGO 7, ILL.
Sales Representatives throughout the United States and Canada

CIRCLE 680 ON READER SERVICE CARD

catalogs and bulletins.....continued

(I-150) Commercial Relays—Catalog, 16 pp. Contains dimensions and characteristics of relays ranging from midget to heavy duty types. Leach Corp, Leach Relay Div, 5915 Avalon Blvd, Los Angeles 3.

(I-151) Meters and Relays—Catalog, 26 pp. Provides electrical specifications and dimensions of military and commercial type panel meters and aircraft relays. Phaostrom Instrument & Electronics Co, 151 Pasadena Ave, S Pasadena, Cal.

(I-152) Motor-Tach Generator—Catalog, 16 pp. Provides performance curves, dimensioned drawings, electrical and mechanical characteristics. John Oster Mfg Co, Avionic Div, 1 Main St, Racine, Wisc.

(I-153) Synchros—Catalog, 16 pp. Presents electrical characteristics, dimensioned drawings of sizes 8 to 15 synchros for military and aircraft use. John Oster Mfg Co, Avionics Div, 1 Main St, Racine, Wisc.

(I-154) Servomotors—Catalog, 20 pp. Lists physical, electrical, mechanical characteristics; furnishes dimensioned drawings of sizes 8 to 29 servomotors for scientific, military and aircraft use. John Oster Mfg Co, 1 Main St, Racine, Wisc.

(I-155) Electronics Components—Catalog, 14 pp. Describes dimensional and electrical characteristics of miniaturized layer-wound capacitors for high temperatures. Also noise filters and power supplies. The Potter Co, 1950 Sheridan Rd, N Chicago, Ill.

(I-156) Relays, Switches—Data sheets, 10 pp. Gives data on miniature, subminiature relays, rotary stepping and crossbar switches. North Electric Co, 553 S Market St, Galion, Ohio.

(I-157) Induction Resolver—Catalog, 23 pp. Explains theory behind the device and some sample applications. Used as phase shifter or to perform trigonometric computations, for example. Reeves Instrument Corp, Garden City, NY.

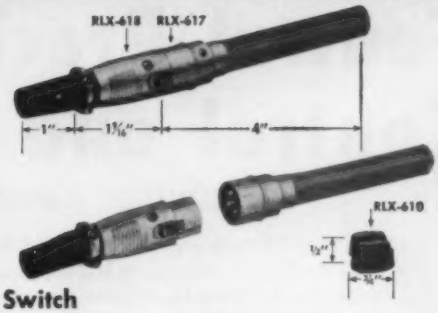
(I-158) Plastic Coated Raceways—Brochure, 22 pp. Gives physical, electrical, thermal and chemical properties of conduit designed for corrosive conditions. Republic Steel Corp, Steel & Tubes Div, 224 E 131 St, Cleveland 8.

(I-159) Raceways—Brochure, 8 pp. Provides specifications for galvanized, enameled steel conduit and plastic piping. Republic Steel Corp, Steel & Tubes Div, 224 E 131 St, Cleveland 8.

(I-160) Electronics Cooling Fans—Brochure, 8 pp. Provides performance curves and specifications for small fans using 400 cps power, larger ones using 60 cps power. Rotron Mfg Co, Inc, Schoonmaker Lane, Woodstock, NY.

continued

POST ELECTRONIC PRODUCTS



NEW!
MH-2-P Magnetic Switch

A new and improved sensing device . . . neatly contained in an epoxy resin shell. The MH-2-P is ideal for industrial applications and is easier to mount in areas of limited access. A quick disconnect Cannon connector eliminates elbow type construction.

The new epoxy resin housing results in less magnetic flux and increased sensitivity. As a consequence, smaller magnets can be used and manufacturer reports a minimum magnetic field transient time of only 8 milliseconds is needed to activate the switch. Operating life is in excess of one billion operations.

Write For Bulletin MH-2-P

Decitron

POST ELECTRONIC PRODUCTS
Division of Reid Brothers Company, Inc.
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CIRCLE 681 ON READER SERVICE CARD

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The only Brochure devoted especially to visual indication by means of read-out lights, data display, placard lights, word and number discs, lenses-with-legends, etc. Applications: data processing, computers, automation, motor-controlled devices, automatic merchandising... Comprehensive, colorful. For a free copy, mail coupon now.

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CIRCLE 483 ON READER SERVICE CARD 483

Fenwal Precision Temperature Control and Detection Devices

CONTROL ELEMENTS OF THERMOSWITCH® UNITS

In Standard Types and Sizes, also Midget and Miniature Units, control is based on a simple and unique differential expansion principle. A single-metal shell always in direct contact with the medium being controlled, contracts or expands instantly with temperature changes, making or breaking totally enclosed electrical contacts.

In Snap-Action Units, control is provided by an expandable liquid acting on a bellows assembly. The bellows motion, actuated by volume changes of the liquid, operates the switch contacts through a push rod. In Fenwal units, the liquid is outside the bellows, adjacent to the shell, for shorter heat transfer path and greater sensitivity.

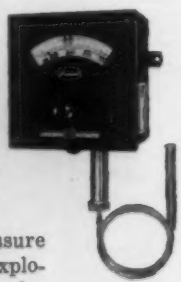
In all Units each control setting is easily adjustable. High resistance to shock and vibration is characteristic, together with hermetic-sealing and many different temperature ranges.

ELECTRONIC CONTROLLERS

Thermistor Indicator Controller (Series 560). For industrial or laboratory applications. Sensitivity 0.25% of scale range. Temperature ranges −100°F to +600°F. Proportional and on-off control. Bulletin MC-140.

Unit Thermistor Controls (Series 535). For all modern control equipment, systems and processes. Utilizes temperature-resistance property of thermistors in transistorized circuit for precise control and reliability. Bulletin MC-179.

NEW TEMPERATURE INDICATING CONTROLLERS



The New Series 541 bulb-and-capillary controllers offer single or dual switch control, choice of four snap-switch types and five temperature ranges: −150°F to +200°F, 50°F to 200°F, 50°F to 300°F, 50°F to 400°F and 50°F to 700°F. Special ranges available on request. Corrosion-proof capillaries and bulbs assure long life and easy operation. Explosion-proof modification available for single switch models. Bulletin MC-176.

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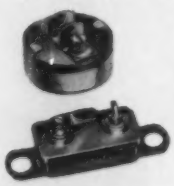
Midget Units. Outside stainless steel shell diameter of ¼″ provides high sensitivity and resistance to vibration, assuring accurate control under severest conditions. Temperature range: −50°F to +500°F. Bulletin MC-124.



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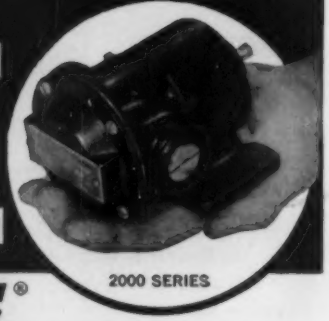

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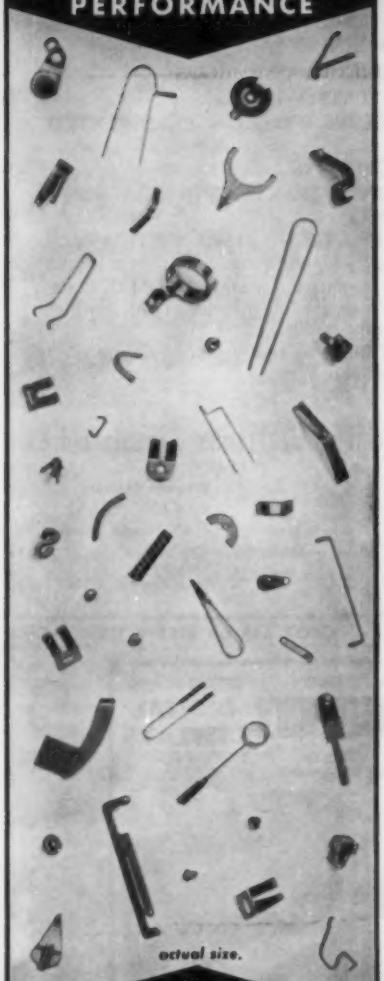

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catalogs and bulletins.....continued

(I-161) Heating Elements—Brochure, 4 pp. Describes construction, physical characteristics and applications of woven flexible resistance wire type. Safeway Heat Elements, Inc, Middlefield St, Middletown, Conn.

(I-162) Relays—Brochure, 4 pp. Contains specifications table covering commercial high contact load types to missile subminiatures. Also stepping motors, other devices. Sigma Instruments, Inc, 170 Pearl St, S Braintree, Mass.

(I-163) Frequency Counters—Brochure, 16 pp. Describes basic counter with 10 cps to 10 mc range and accessories to extend range and versatility. Northeastern Engineering, Inc, 25 S Bedford St, Manchester, NH.

(I-164) Panel Instruments—Bulletin, 8 pp. Specifications are given for such instruments as voltmeters, ammeters, wattmeters, VU meters, galvanometers and others. Simpson Electric Co, 5200 W Kinzie St, Chicago 44.

(I-165) Panel Meters—Brochure, 4 pp. Gives dimensions, ranges, illustrations of ac and dc voltmeters, ammeters, wattmeters and others. Simpson Electric Co, 5200 W Kinzie St, Chicago 44.

(I-166) Electrical Supplies – Catalog, 20 pp. Furnishes descriptions and specifications of wire, cable, harness, flexible connectors, conduit supports, commutator maintenance equipment and other electrical products. Sittler Corp, 18 N Ada St, Chicago 7.

(I-167) Potentiometers—Chart. Lists electrical, mechanical characteristics, dimensions, environmental specifications met for wire-wound precision potentiometers. Spectral Electronics Corp, 1704 S Del Mar Ave, San Gabriel, Cal.

(I-168) Potentiometers—Catalog, 100 pp. Furnishes mechanical and electrical characteristics of single and multiturn wirewound, linear and nonlinear precision potentiometers. Spectrol Electronics Corp, 1704 S Del Mar Ave, San Gabriel, Cal.

(I-169) Raceways—Bulletin, 8 pp. Shows dimensions, installation methods for modular panel raceways. Stahlin Brothers, Inc, Belding, Mich.

(I-170) Variable Transformers – Catalog, 22 pp. Gives circuits, dimensions, ratings for panel, bench, gaged, motor-driven types. Standard Electrical Products Co, 2240 E Third St, Dayton, Ohio.

(I-171) Tube Shields and Retainers—Bulletin, 6 pp. Describes varieties for different chassis, tubes, connection methods and with several finishes. The Staver Co, 41 N Saxon Ave, Bay Shore, NY.

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(I-173) Trimmer Potentiometers—Catalog, 8 pp. Provides dimensions, wiring diagrams and specifications for miniature rotary types. Subminiature Instrument Corp, 3705 Sunnyside Dr, Riverside, Cal.

(I-174) Electronic Components—Catalog, 34 pp. Provides dimensions, specifications and circuits for switches, plugs, jacks and connectors. Switchcraft, Inc, 5555 N Elston Ave, Chicago 30.

(I-175) Semiconductors—Brochure, 8 pp. Provides characteristics of transistors, diodes, microwave semiconductors, rectifiers and others. Sylvania Semiconductor Div, Sylvania Electric Products Inc, 100 Sylvan Rd, Woburn, Mass.

(I-176) Terminals—Catalog, 43 pp. Shows terminals, connectors, cable ties and hand tools and machinery for installation. The Thomas & Betts Co, Inc, 16 Butler St, Elizabeth, NJ.

(I-177) Terminals and Connectors—Catalog, 43 pp. Describes pressure fitted types as well as hand and production tools. The Thomas & Betts Co, Inc, 16 Butler St, Elizabeth, NJ.

(I-178) Semiconductors—Catalog, 12 pp. Furnishes electrical specifications and dimensions of silicon and germanium semiconductor devices such as diodes, transistors and others. Transitron Electronic Corp, 168 Albion St, Wakefield, Mass.

(I-179) Fuses—Catalog, 2 pp. Lists prices, ratings and accessories. Trico Fuse Mfg Co, 2948 N Fifth St, Milwaukee 12, Wisc.

(I-180) Heating Elements—Brochure, 8 pp. Describes capabilities for manufacturing open coil and strip resistance type elements. H W Tuttle & Co, 805 S Evans, Tecumseh, Mich.

(I-181) Porcelain Shapes—Catalog, 8 pp. Provides dimensions of shapes used in electrical installations. Includes cleats, tubes, knobs, others. The Universal Clay Products Co, Box 1631, Sandusky, Ohio.

(I-182) Electrical Insulating Sleeving – Brochure, 8 pp. Provides 25 samples with brief descriptions of each. Includes tables of sizes and grades. Varflex Corp, 512 W Court St, Rome, NY.

(I-183) Neon Glow Lamps—Catalog, 10 pp. Furnishes specifications and price lists for lamps used for indicators and circuit components. Signalite Inc, Neptune, NJ.

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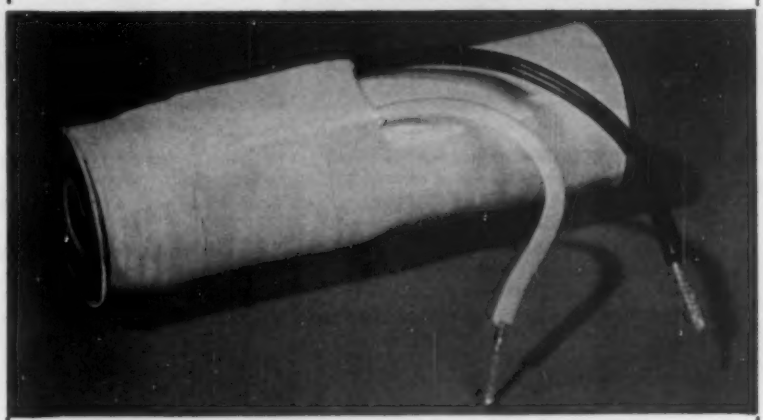

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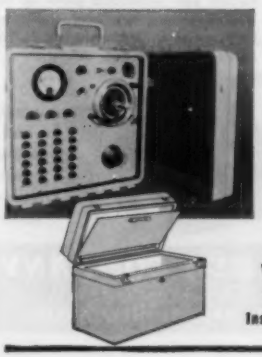

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(I-184) **Readout Instruments**—Bulletin, 12 pp. Provides specifications and circuits of digital readout instruments for handling, displaying, storing and transferring data. Union Switch & Signal, Div of Westinghouse Air Brake Co, Braddock Ave, Pittsburgh 18.

(I-185) **Miniature Relays**—Bulletin, 12 pp. Contains dimensioned drawings, electrical and environmental data for ac and dc relays used in missiles, airborne and electronic equipment. Union Switch & Signal, Div of Westinghouse Air Brake Co, Braddock Ave, Pittsburgh 18.

(I-186) **Resistors**—Catalog, 64 pp. Characteristics of vitreous enamel power resistors explained and graphed to aid selection. Ratings range from 3 to 550 watts. Ward Leonard Electric Co, 15 South St, Mount Vernon, NY.

(I-187) **Dry Transformers**—Catalog, 34 pp. Gives electrical and dimensional data for following types: power circuit, buck and boost, control, machine tool, signalling, ignition and luminous tube. Dongan Electrical Mfg Co, 2998 Franklin St, Detroit.

(I-188) **Cord Sets and Wire**—Catalog, 60 pp. Provides dimensioned drawings and electrical ratings for molded-on caps, plugs, connectors, accessory devices and insulated wire. Miller Electric Co, 120 Main St, Pawtucket, RI.

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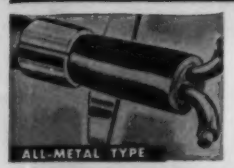

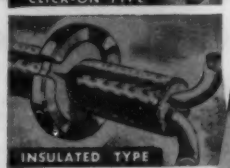

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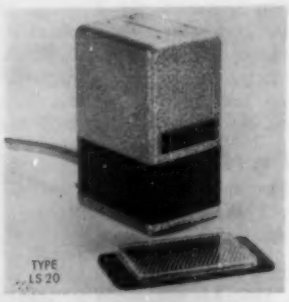

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SECTION J

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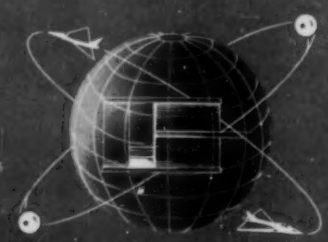

Design Abstracts 492

16 Ways to Mount Hydraulic Cylinders 494

How to Classify Fluids by Viscosity
by R. A. Minard 495

Gas Nomograph for Converting to Standard Cubic Feet
by F. Caplan 497

Reducing Leakage from Hydraulic Systems
by R. Q. Sharpe 498

7 Relief Valves for Portable Equipment
by C. A. L. Ruhl 502

15 Jobs for Pneumatic Power 506

DESIGN ABSTRACTS

HYDRAULIC FLUIDS

This article discusses the main factors associated with the selection of a hydraulic fluid for optimum service.

The production or service capabilities of any hydraulic equipment are closely linked to the characteristics of the fluid employed in the system. As a generalization, the right fluid is always the cheapest in the long run, giving both better quality and quantity of production (or service) and minimizing both power consumption and maintenance cost. An inferior fluid is almost inevitably a source of costly trouble, sooner or later.

A majority of hydraulic systems employ mineral oil fluids, although water, water-base and synthetic fluids have their specific applications. Water has the advantage of being negligible in cost and therefore particularly attractive in systems where fluid losses may be high. It is also a "safe" fluid from the point of view of contamination and fire risk resulting from a burst. Mineral oils have the specific advantage of being inherently noncorrosive and can be formulated with high chemical stability and excellent lubricating properties. Water-base fluids provide a non-inflammable medium with better overall properties than ordinary water and may be particularly attractive where the fire risk is high, as on die-casting machines, aircraft hydraulics, etc. Synthetic fluids range from those with noninflammable characteristics to others formulated for high-temperature operation. All are more costly than normal mineral oil fluids and are produced for specific rather than general application.

It is a requirement of any hydraulic fluid that it should be capable of performing a number of duties. Apart from all pure pressure transmission it must also provide lubrication for pumps, valves and pistons, remain chemically inert and be stable physically. All these factors have become more and more important—even critical—with modern hydraulic machines which may be called upon to work within very fine limits at high speeds, and often at very high pressures.

"Application Aspects of Hydraulic Fluids," Mechanical World and Engineering Record, April 1960, 31 King Street West, Manchester 3, England.

*

Vacuum Pump Oils

Preformance of a high vacuum pump depends greatly on the quality of its sealing oil. Special oils of low vapor pressure are employed to obtain the best results in the evacuation process. However, in such service the oil is exposed to contamination from air and other vapor media that the vacuum pump has to handle, which reduce the oil's sealing and lubricating effectiveness. Removal of these contaminants through continuous conditioning of the oil not only improves its lubricating value, but also increases pumping speed and ultimate vacuum of the system.

"Conditioning of Vacuum Pump Oils," S. F. Bowser Co, Hamilton, Ontario, Canada, Lubrication Engineering, Dec '59, 5 No. Wabash Ave, Chicago 2, Ill.

*

Thermal Conductivity of Hydraulic Fluids

Determinations of the thermal conductivity of ten synthetic base and five mineral base lubricating fluids were made. Conductivities over the temperature range of 70 to 500F were found. A total of forty fluids were tested.

"Thermal Conductivity of Lubricating Oils and Hydraulic Fluids," D. W. McCready, University of Michigan, Research Institute. WADC Technical Report 58-405, ASTIA Document No. 211693. Wright Air Development Center, Air Research and Development Command, United States Air Force, Wright-Patterson Air Force Base, Ohio.

*

Which Type Pump Casing?

Centrifugal pump casings perform a hydraulic function, converting kinetic energy developed by the impeller into potential pressure energy. This may be accomplished with a single volute, double volute, or a concentric casing. The most suitable type for a particular pump depends on overall design features and objectives, including a detailed study of radial load problems. A brief review of the differences between types of pump casings shows the factors influencing a pump designer's choice.

"Which Type Pump Casing is Best?" Power and Fluids, Volume No. 2, Winter, Worthington Corp, Harrison, New Jersey.

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Pneumatic Signal Systems

As processing plants grow larger and more complex, correct installation of measurement and control signal transmission systems becomes increasingly important. Without reliable signals, personnel safety, plant performance, and duration of processing runs may be jeopardized during normal and emergency operation. Careful design, equipment selection, and construction assures satisfactory transmission systems at acceptable costs. Consideration must be given to: Protecting signal leads to reduce possibility of damage by fire or mechanical shock; excluding hazardous or noxious fluids from control rooms; installing reliable air supplies; providing facilities for manual control, for testing, and for ready access to instruments.

"Installing Pneumatic Signal Transmission Systems," American Petroleum Institute, Committee on Refinery Equipment, Subcommittee on Instruments. Control Engineering, January 1960, 330 W 42nd Street, New York 36, New York.

*

Transferring Liquefied Gases

Liquefied gases, such as hydrogen, oxygen, nitrogen, and helium, are widely used as refrigerants in basic research in chemistry, physics, and engineering. More recently these liquids have also come to play an essential part in the propellant systems of rockets, missiles, and satellites. In general, the low-temperature liquids are transported from the liquefier to

the experimental setup in insulated, Dewar-type containers.

The current interest in liquefied gases, both in private industry and throughout government, has led the Bureau of Standards to take a second look at accepted methods for long-distance transportation of these fluids. The results of a recent theoretical study indicate that the pipeline method, now employed only in relatively short-distance transfers, can be extended to appreciable distances provided there is an awareness of the performance limitations introduced by undesirable cooldown characteristics. The design of such a system, which in many cases could undoubtedly increase efficiency safety, and economy, is relatively straight-forward.

"Transferring Liquefied Gases by Pipeline." Technical News Bulletin, May 1960, National Bureau of Standards, US Dept of Commerce, Washington 25, DC.

*

Hydrostatic Thrust Bearings

Based on a theoretical and experimental analysis of two types (circular step and circular annular) of hydrostatic thrust bearings, design equations are given for load-carrying capacity, stiffness, flow for three types of flow restriction: orifice, capillary, constant flow.

"Theoretical and Experimental Analysis of Hydrostatic Thrust Bearings," Elwell and Sternlicht, General Electric Co; ASME paper 59-A-152. ASME, 29 W 39th St, New York 18.

*

Sealing High Temperature Hydraulic Systems

The sealing of a liquid whether it be for a static or dynamic application is a most important task facing the designers of fluid systems for new and advanced flight vehicles when the loss of a seal could spell the difference between success and failure of a mission. The jobs that a seal is called upon to accomplish are many. Satisfying a host of conditions such as extremely cold to extremely hot temperatures, nuclear radiation, zero to several thousand pounds of pressure, with absolute zero leakage poses some very formidable problems.

Close cooperation between the chemist, the metallurgist and the designer is needed now more than ever before as is a better understanding of the problems facing each in his particular work.

"Static and Dynamic Sealing in High Temperature Hydraulic Systems," William E. Mayhew, Republic Aviation Corporation. Society of Aircraft Materials and Process Engineers, P. O. Box 39632, Griffith Sta, Los Angeles 39, Calif.

*

Tadpole Seals

This paper describes the various components used in the manufacture of "Tadpole Seals." Tadpole tapes derive their name from their shape. They are usually composed of a body or bulb and a tail. They are mainly used as static seals. In general they seal against air or gases under low pressure differential. Their chief function is to prevent the passage of low pressure gases, or to seal against the passage of dust, dirt, or flame. They may be made from one material, such as an elastomer extrusion, or they can be made from many different components. These seals may vary in size and shape. They can be endless, circular, or conceivably any shape within the limitations of manufacture. They can have no tail, a centered tail, a tangent tail, or a double bulb. The tail is used to hold the bulb in position. The bulb accomplishes the seal.

The most used material for the core or body of the tadpole, that must withstand temperatures of 500F and over, or flame penetration, is usually a wire mesh.

"Tadpole Seals: Components, Design, and Use," R. H. Holmes, General Asbestos and Rubber Division, Raybestos-Manhattan, Inc. Society of Aircraft Materials and Process Engineers, P. O. Box 39632, Griffith Sta, Los Angeles 39, Calif.

*

Valve-sizing

Using a digital computer to size-control valves requires an evaluation of the equations usually supplied for such purposes. Given in this article are equations for liquid, gas, steam and Dowtherm, all of which can also be solved with a slide rule.

"Valve-sizing Equations for Computers," Orval P. Lovett, Jr, E I du Pont de Nemours & Co; ISA Journal, Nov '59, 313 Sixth Ave., Pittsburgh 22.

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Multi-anvil, Wedge-type, High-pressure Generator

Apparatus for generating pressures in excess of 100,000 atmospheres is described. Based on application of force by an anvil against each face of a solid polyhedron.

"Compact Multi-anvil Wedge-type High Pressure Apparatus," Lloyd, Hutton and Johnson. Journal of Research of the National Bureau of Standards, Section C, JulySept 1959, Washington 25, DC.

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Piston Gage for Pressures Below 0.5 in. Hg

A tilting, air-lubricated gage for differential pressures up to 0.5 in. of Hg is described, which is reported to provide resolution of better than 1:100,000, full scale.

"A Tilting Air-lubricated Piston Gage for Pressures Below 0.5 in Hg," U O Hutton, Journal of Research of the National Bureau of Standards, Section C, July-Sept, 1959, Washington 25, DC.

*

Hydrostatic Gas Bearings

Based on Euler's equation, expressions for such parameters as pressure profile, gas flow rate, gap height, load-carrying capacity of pad and step bearings are developed. These theoretical findings were substantiated by tests based on measurements of pertinent data derived from bearings of various configurations. Test equipment and procedure are described for the experiments.

"Hydraulic Gas Bearings," John H. Laub, California Institute of Technology. ASME paper 59—Lub-1, ASME, 29 W 39 St, New York 18.

From: American Machinist/Metalworking Manufacturing

16 ways to mount . . . HYDRAULIC CYLINDERS

Simple methods include: Bored holes, flange brackets, angle brackets, horizontal brackets and trunnion brackets.

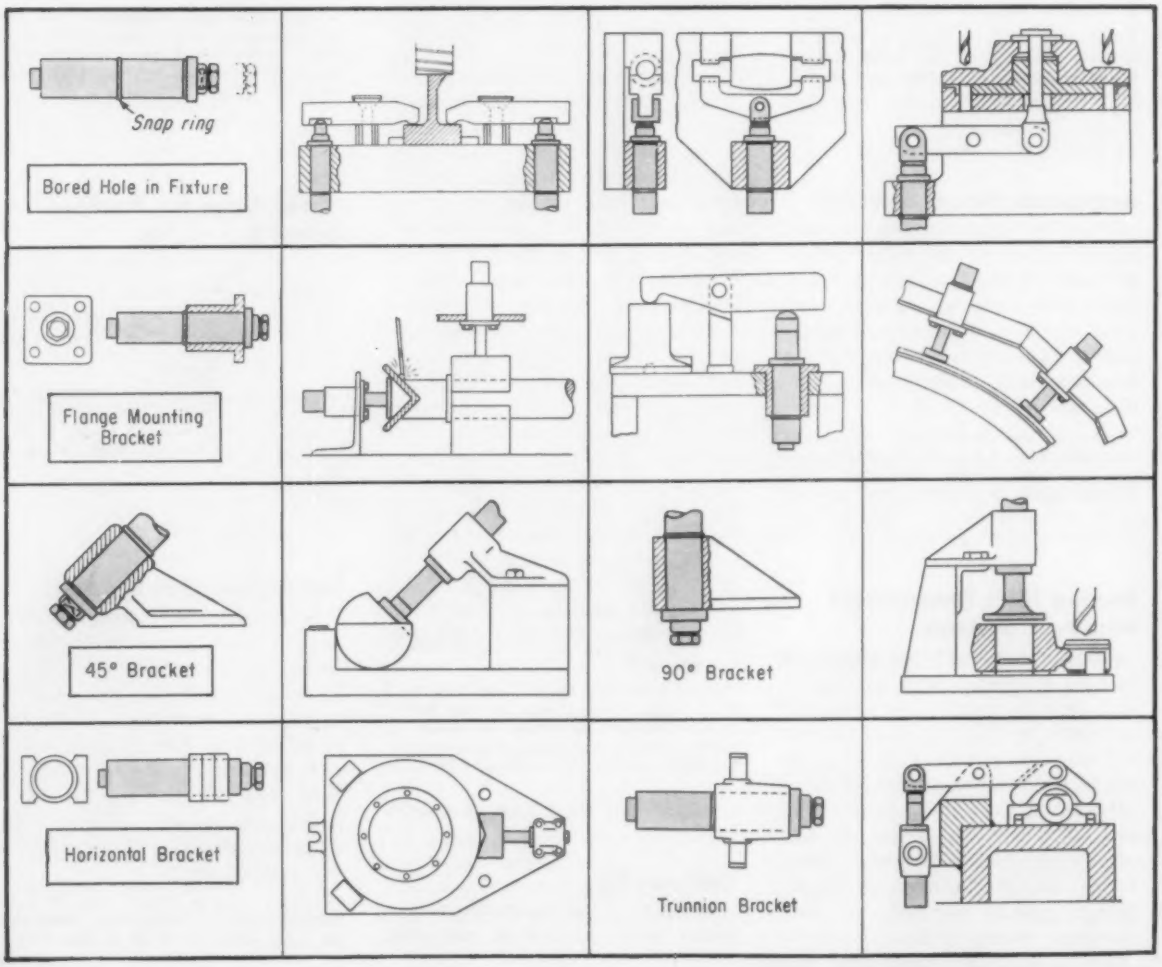
Cylinders can be mounted in any position. They can be held directly in a hole bored in the fixture, because all cylinders have a shoulder and snap retaining ring. Also, all cylinders can be mounted by means of standard brackets fastened to the fixture. Also, brackets, and appropriate linkages as there is now available a swing clamp (with integral cylinder) that can be fastened to T-slots in a machine table.

Mounting brackets are of the following types: flanged, 90°, 45°, horizontal and trunnion. With these required, the designer can assemble a fixture that will cope with virtually any clamping problem.

Below are illustrated three different applications of the basic mounting method as illustrated in the first column of the diagrams.

REFERENCE:

Hydraulic Clamping Cuts Floor-to-Floor Time by Rupert Le Grand, Senior Associate Editor, American Machinist, published Feb 8 '60 p. 106-108.

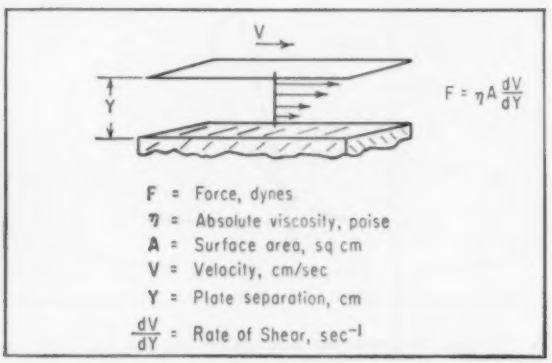


From: Instruments & Control Systems

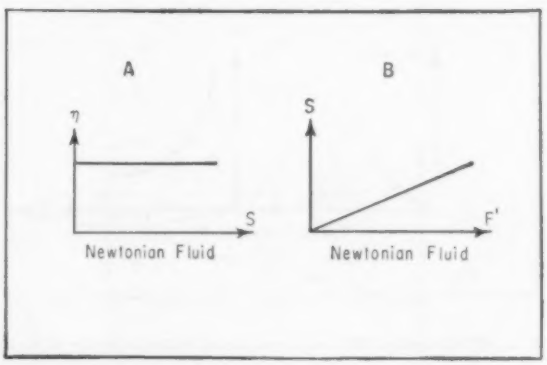
how to . . . CLASSIFY FLUIDS BY VISCOSITY

Five shear-rate and viscosity diagrams for Newtonian, non-Newtonian and thixotropic fluids.

R. A. MINARD
Technical Sales Manager
Brookfield Engineering Labs, Inc.
Stoughton, Mass.


V
Y
$F = \eta A \frac{dV}{dY}$
F = Force, dynes
η = Absolute viscosity, poise
A = Surface area, sq cm
V = Velocity, cm/sec
Y = Plate separation, cm
$\frac{dV}{dY}$ = Rate of Shear, sec^{-1}

1. ABSOLUTE VISCOSITY is defined as shear stress per unit area *(F/A)* divided by rate of shear. It is constant for Newtonian liquids. Water, hydrocarbons, mercury are examples.



2. VISCOSITY vs rate of shear for a Newtonian fluid; viscosity remains constant (A). B shows rate of shear vs force for a Newtonian fluid showing linear, proportional relationship.

Control of many process operations such as pumping, stirring, etc., depends upon the type of fluid involved. It is necessary to know the various viscosity groups to classify any particular fluid properly.

Resistance to fluid flow can be expressed as

Viscosity = shear stress/rate of shear

This formula is illustrated in Fig. 1.

If a moveable plate with an area of one square centimeter is placed one centimeter away from a fixed plate of the same area, and if a fluid is contained between these plates, the force required to move the plate is proportional to the rate of shear to which the fluid is subjected.

A material requiring a shear stress of one dyne per square centimeter to produce a rate of shear of one inverse second has a viscosity of one poise, or 100 centipoises. It happens that water at room temperature has a viscosity of one centipoise.

NEWTONIAN FLUIDS

Fig. 1 shows that shearing a fluid involves the motion of intermediate layers of that fluid at different velocities. The velocity gradient, or rate of shear, is expressed by the term dV/dY. Newton assumed that the force would be proportional to this rate of shear—that is, that a fluid's viscosity would remain constant. Hence, when the viscosity is a constant, the material is called Newtonian. Such fluids include water, most hydrocarbons, mercury, and certain other commercial fluids. A plot of viscosity vs. shearing rate for such a material is shown in Fig. 2.

When the rate of shear is increased and the viscosity remains the same, a shearing force/rate-of-shear curve for the same material will be linear, Fig. 2.

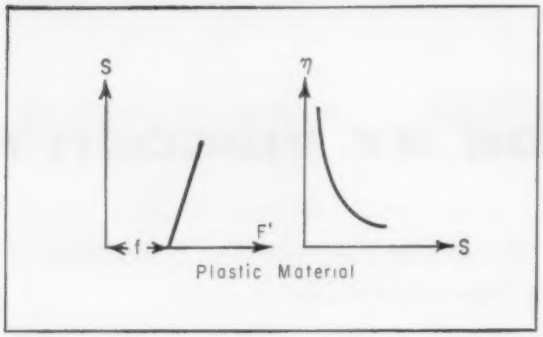
This rheogram shows that moving the fluid twice as fast will take twice the push—i.e., the shearing force increases in the same proportion as the rate of shear.

NON-NEWTONIAN FLUIDS

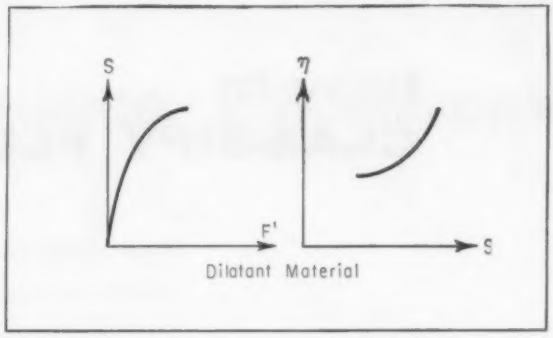
Non-Newtonian materials have three main types of flow —pseudo-plastic, dilatant, and plastic.

Plastic

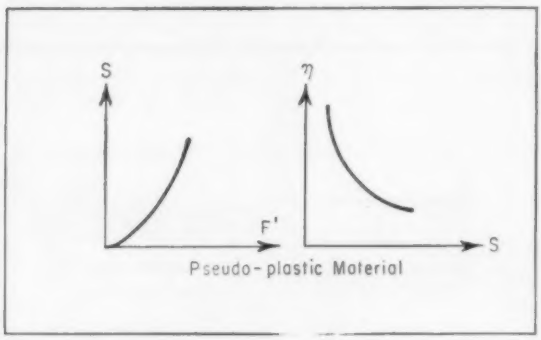
A plastic, Fig. 3, shows a decreasing F'/S ratio after a yield value. A certain force must be applied to the ma-



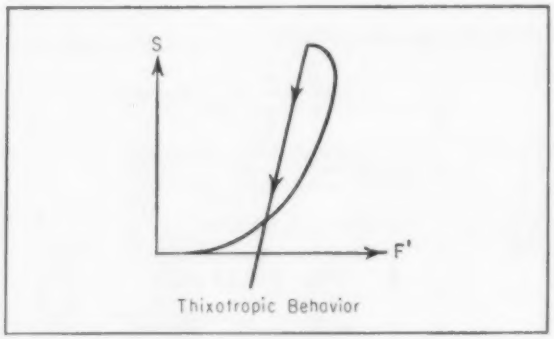
3. SHEAR RATE vs force and viscosity vs shear rate for a plastic Note threshold force before flow starts.



4. DILATANT MATERIAL "firms up" at increasing rates of shear. Pumping speed is important with such materials.



5. A PSEUDO-PLASTIC loses viscosity at increasing rate of shear.



6. TYPICAL THIXOTROPIC RHEOGRAM; the plot will shift with time also.

terial before any shear (or flow) takes place; the viscosity will approach infinity when rate of shear is low.

Dilatant

A dilatant material, Fig. 4, shows the opposite effect. The F'/S ratio increases with increasing S. The viscosity at increasing shear can reach the point where the fluid becomes solid. Hence it is important to know whether you are working with a dilatant fluid, say, before you try to increase flow by increasing pump speed—the dilatant material can solidify and break the pump.

Pseudo-plastic

With a psuedo-plastic material, Fig. 5, the viscosity decreases as the rate of shear increases.

THIXOTROPY

Another phenomena is thixotropy, Fig. 6, defined as a "reversible gel-sol-gel transition." This introduces an irregular time factor into the measurement of viscosity. In Fig. 6 measurements of shear stress have been made continuously while the shearing rate has been increased to a particular value and then decreased. Note that both duration of the shear and the rate at which it is applied affects the measured viscosity.

Viscometers can be divided into two principal types—those measuring force and those measuring time—these variables being related to viscosity according to the particular instrument used.

VARIABLE vs CONSTANT RATE OF SHEAR

In general, those industrial viscometers in which a time measurement is made proportional to viscosity do not measure at a constant rate of shear.

Force-type viscometers measure shear force at constant shear rate. Units of force can be calibrated directly in viscosity units.

This method eliminates the uncertainty that results from measuring the mean of an unknown flow curve made over unknown rates of shear.

TEMPERATURE EFFECTS

The relationship between a fluid's viscosity and its temperature also must be considered. The viscosity of most materials will vary by approximately 10% for a change of one degree centigrade.

REFERENCE:

Viscosity of Fluids by R. A. Minard, Brookfield Engineering Labs, Inc, Stoughton, Massachusetts. Published in Instrument & Control Systems, June '59, p. 876.

gas nomograph for . . .

From: Power

CONVERTING TO STANDARD CUBIC FEET

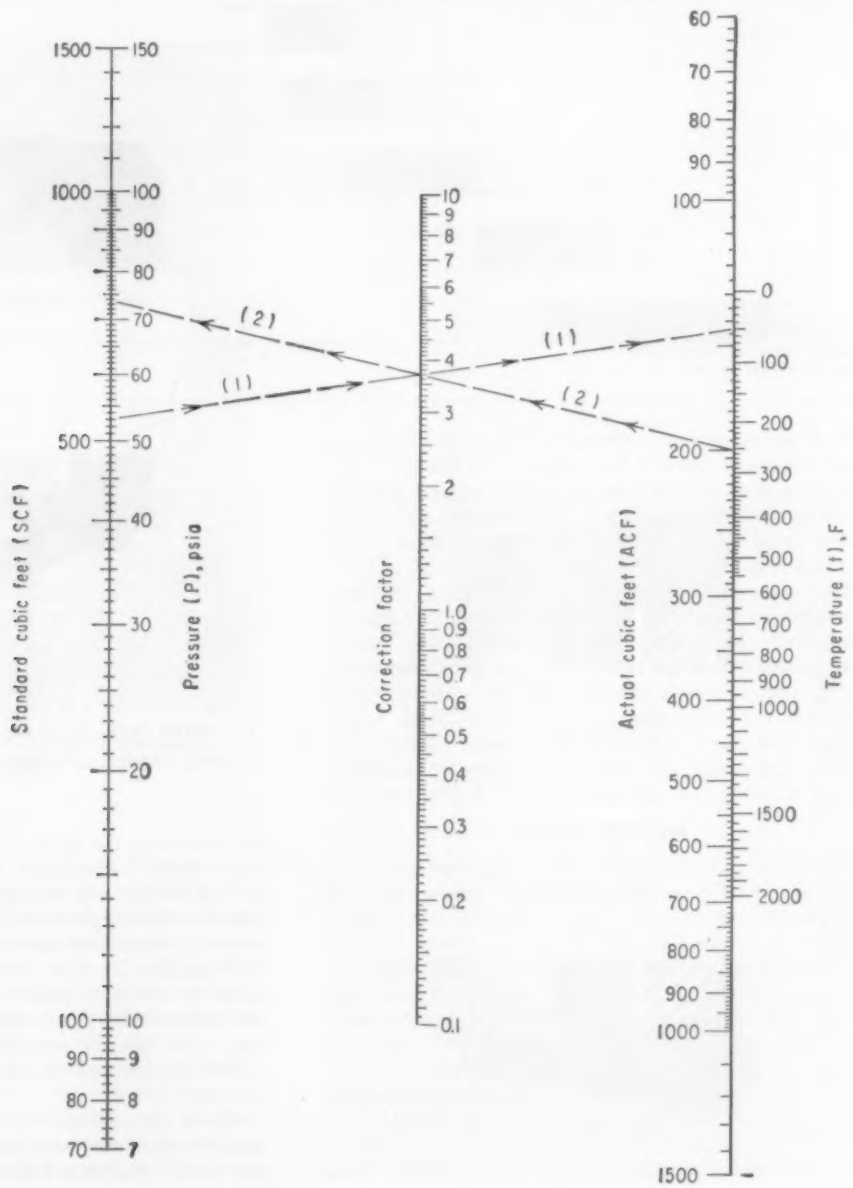
Conversion of actual gas or air volumes to standard cu ft (volume at 14.7 psia and 60 F) can be made by the formula:

$$SCF = ACF \times \frac{P}{14.7} \times \frac{520}{(t + 460)}$$

The nomograph below provides a quick aid for finding the answers.

Example: What is *SCF* per min corresponding to 2000 *ACF* per min at 533 psia and 50F?
Solution: Align $P = 533 = (53.3)\ (10)$ with $t = 50$; align intersection of correction-factor scale with $ACF = 2000 = (200)\ (10)$ and read *SCF* intersection of 740. For values beyond either *P* or *ACF* scales, scale value is multiplied by *N*, then scale value of *SCF* must be multiplied by *N*. Since both *P* and *ACF* scales were multiplied by 10 final answer is 740 x 100 or 74,000 *SCF* per min.

F. CAPLAN
Kaiser Engineers
Oakland, California



REFERENCE:
Nomograph for Converting to Standard Cubic Feet by F. Caplan, Kaiser Engineers, Oakland, California. Published in Power, Data Sheet No. 330, February 1960, p. 94.

From: Lubrication Engineering

REDUCING LEAKAGE FROM HYDRAULIC SYSTEMS

Leakage of fluid from hydraulic systems is a costly and undesirable problem; factors that must be considered in both design and operation are presented here.

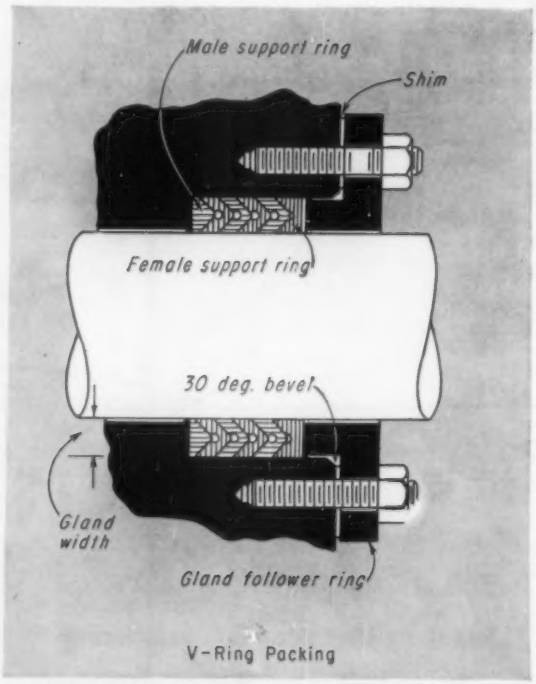
R. Q. SHARPE
Manager Industrial Technical Div,
Socony Mobil Oil Co. Inc.

Fluid power provides substantial force, quick response, ready control of speed, a high degree of flexibility in lay-out and remote control, good dependability, and generally low maintenance costs. This article is directed particularly at one phase of hydraulic equipment; that of fluid leakage and how to control it.

Hydraulic systems have two general classes of joints through which the fluid may be lost. These are **moving joints** and **static joints.** Moving joints include rod or ram packings, seals for valve stems, pump or fluid-motor shafts, and in some instances seals on pistons (which influence internal leakage). Static joints from which leakage may occur include threaded joints, tube fittings, O-rings, Quad-rings and other special forms of elastomers as well as sheet gasket material, used to seal static joints.

MOVING JOINTS

In order to perform satisfactorily at high pressures, seals of moving joints of hydraulic systems are pressure-actuated and generally self-sealing. When proper seals are installed in properly designed grooves or packing glands, they do an adequate job without requiring frequent adjustment or tightening which, if engaged in, may actually destroy the packing and aggravate the problem. Fig. 1 illustrates a conventional V-ring packing used in connection with piston rods or rams on pistons and occasionally for rotating shafts. When installed in a suitably dimensioned gland, these V rings are open toward the high-pressure side and dimensioned to provide a degree of preloading. The fluid under pressure tends to spread the V open,

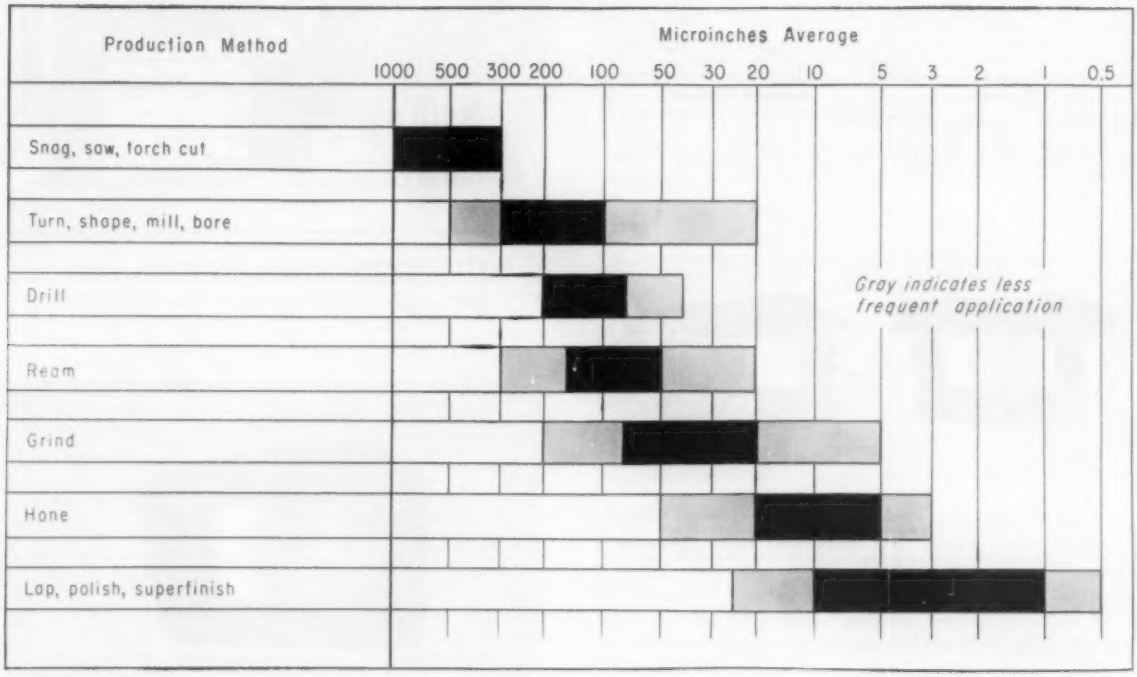


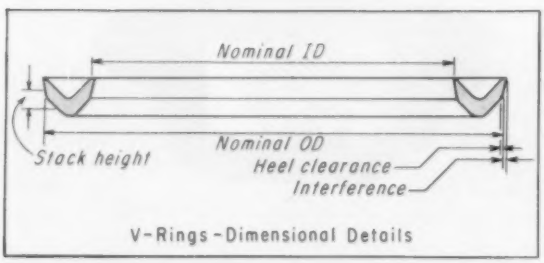
1. . V-RING SEAL. Gland follower ring is bolted metal to metal with a shim inserted to prevent the follower ring from exerting excessive pressure on the sealing rings.

thus increasing the tightness of the seal and its ability to stop leakage. The higher the pressure the tighter the seal. Although such molded seals do not appear to have high dimensional precision, the pre-load is actually determined by a radial interference dimension of from 0.02 to 0.035 in, Fig. 2. They must, therefore, be carefully installed to eliminate possible damage to the sealing lips and tightened lightly according to recommended practice. They must never be overtightened or the individual rings will become crushed and no longer be able to seal high pressures.

This or any other type of seal will not stop leakage when used in connection with rods, rams, or cylinders having poor finish. Statistics indicate that a seal used on a sur-

Surface Finishes by Common Production Methods

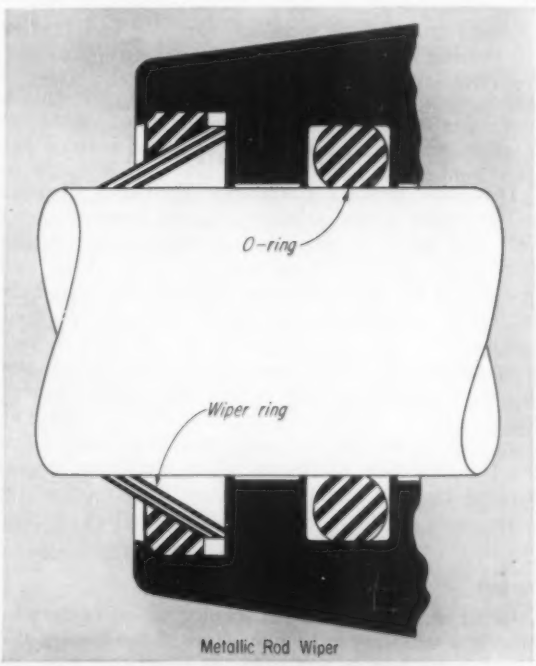




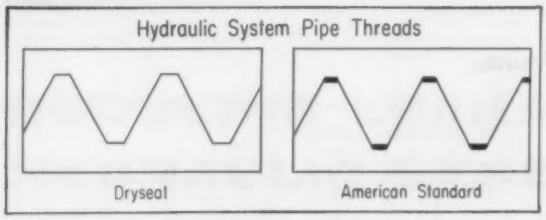
2. . THE SIDES of a V-ring flare slightly so that when installed the pressure lips will be preloaded.

face having a finish of 5 to 20 microinches will supply many times the life of one used on surfaces with a finish of even 100 to 200 microinches. These differences are even more significant where homogeneous rubber seals are in service. Table I gives us some conception of what this should mean to the designer in relation to normal machining methods. From this it will be observed that maximum seal life can be expected only when surfaces of rods, rams and cylinders are ground or honed. Care must be taken, therefore, to protect and maintain the smooth surfaces of rods, rams, shafts, and cylinders.

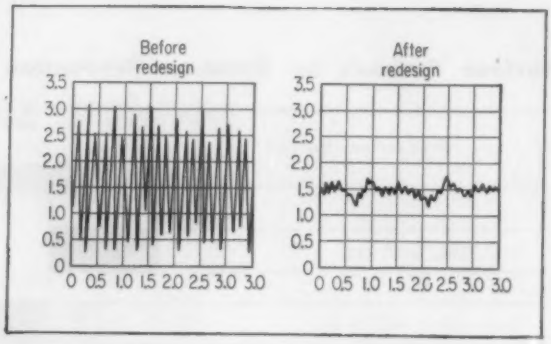
As another example, many seals are ruined prematurely when abrasive dirt is carried into the seal by the rod or



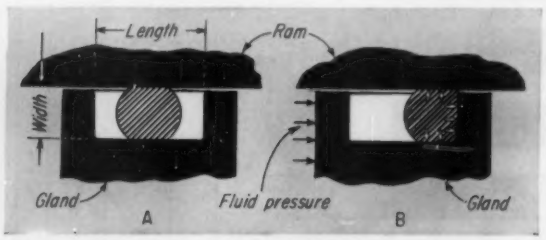
3. . WIPER RINGS made of metal cones backed by rubber are sometimes used to keep harmful dirt out of the packing.



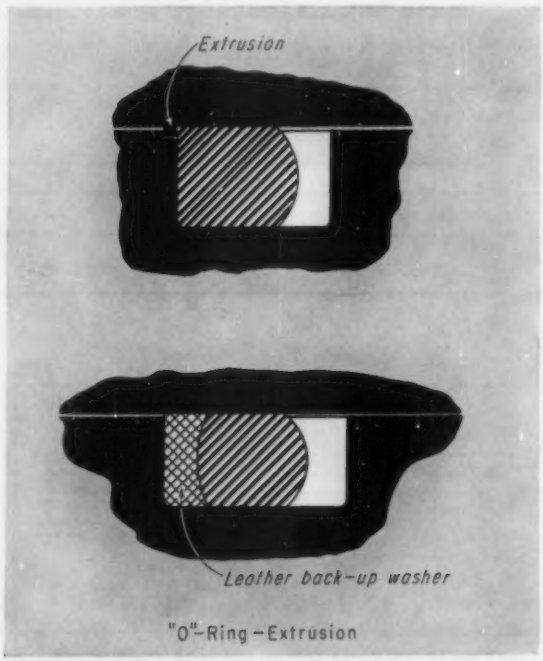
4. . DRY SEAL and American Standard Pipe Threads. Note that the Dry Seal threads bottom against the root and thus prevent spiral leakage.



5. . CURVES SHOWING variations in accumulator pressure resulting from high frequency surges before and after circuit design modification.



6. . O-RING ACTION. When pressure is applied to synthetic O-rings, they deform and transmit pressure equally in all directions. At A an O-ring is shown in a groove of exaggerated length. When fluid pressure is applied the O-ring moves against one wall of the groove as at B.



7. . WHEN RECOMMENDED clearance or pressure is exceeded, the O-ring tends to extrude into the clearance as shown at the top. Where extrusion is experienced, leather backup washers should be used.

ram. Effective means should be provided for protecting seals from such materials. This is particularly necessary where O-ring seals are used on reciprocating rods. Fig. 3 illustrates one type of metallic wiper ring found to be very effective in the protection of seals in such applications. Protective rings may be designed into new equipment or may be readily added to existing installations.

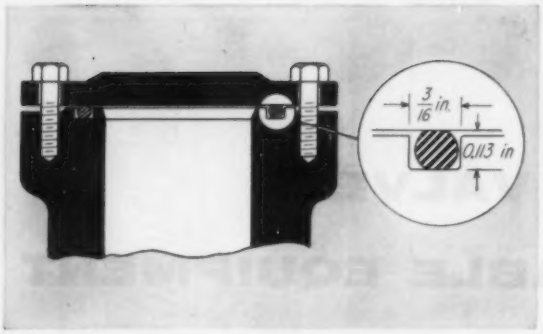
STATIC JOINTS

The Joint Industry Conference Hydraulics Standard has been most helpful in influencing the increased use of SAE 1010 dead soft seamless steel tubing which provides flared joints that should not split or break. They have discouraged the use of threaded pipe and encouraged the welding of connections where black pipe must be used. Specific advantages are offered by the adoption of such recommendations. With American Standard tapered pipe threads, the tolerances may permit spiral leakage as illustrated in Fig. 4. Practically all of the standard tubing fittings used in industrial hydraulic equipment today utilize the Dry Seal type of thread, which establishes contact between the root and tip of mating threads before the flanks come together. Spiral leakage, therefore, is eliminated.

Surges

In the installation of either seamless tubing or threaded pipe, it is necessary to be fully aware of the damage that often results from system surges or vibration. Even the best joints will not long withstand the severe stresses imposed on them from high-frequency surges or abrupt halting or reversal of long columns of fluid flowing through the system at high speed. The sudden cut-off of a valve may start vibrations that will shake a machine weighing many tons. Shocks such as this and regular high-frequency vibration cause joints to fatigue, lines to rupture, and machines to be shut down with large fluid and production losses. Three preventive measures will greatly reduce the incidence of such troubles:

1. Modifying existing controls, or properly designing



8. . **APPLICATION** of O-ring gasket to seal parallel surfaces.

new systems to utilize to the utmost decelerating valves or other means of avoiding abrupt directional changes.

2. Circuit design or modification to reduce to a minimum high-frequency surges in the fluid stream. This is often aided materially through the installation of small accumulators to flatten out pressure peaks. See Fig. 5.

3. Use of an adequate number of proper clamps to prevent lines from moving.

HOSES AND GASKETS

Most hydraulic circuits employ some flexible hoses. Quality grades of high-pressure hoses available today are well designed for the service intended and will render long and satisfactory service if properly selected, installed and maintained. It must be recognized that these are intended to move in service and they must be installed with that thought in mind. Hoses try to straighten out as pressure surges hit them. These rapid, spasmodic movements occur frequently and may total hundreds of thousands of cycles within the life of a piece of hose. Therefore, avoid: Installing hoses with short or double bends; having short bends near hose fittings; having hoses support the weight of any other component; having hoses in rubbing contact with any object—including other hoses.

Fluid loss due to hydraulic line breakage is such an important item that other influencing factors should be mentioned. The principal cause of breakage, which most often occurs at pipe or tubing fittings, is due to system characteristics which may subject joints to high or pulsating surge pressure and the resulting serious strains. The problem of surging can be minimized by modification of the equipment or its sequence of operation. It must be recognized that large lines, threaded, welded or with tubing fittings all transmit shock from one system component to another. Adequate isolation of components by means of flexible hoses or swivel joints will help alleviate the mechanical vibration phase of this problem. This will also provide for expansion and contraction with temperature changes which may otherwise place a strain on rigid lines and connections.

Gaskets

The most common of the modern pressure-actuated seals for static joints are probably the O-ring and the Quad-ring. The Quad-ring is less subject to rolling or twisting than the O-ring. Each of these may be made of elastomers ranging from neoprene and Buna N to silicone and PTFE. Each material has its own significant properties, but since neoprene and Buna N are more common with oil, discussion will center about them. First, it must be understood that a suitable material must have good resilience, proper hardness to withstand mechanical factors of pressure and movement within its groove; compatibility with the fluid in service; chemical and oxidation stability suitable for the temperatures involved (in a hydraulic system usually below 200 F) and good mechanical stability. Fig. 6 shows that an O-ring installed in a suitably designed and dimensioned groove is always under preload, so there can be no leakage, even when the system is not under pressure. On the other hand, a suitable O-ring will satisfactorily hold and seal pressures up to 1000 psi without back-up washers and up to 5000 psi when suitably backed up to prevent extrusions as shown in Fig. 7.

Fig. 8 shows the installation of an O-ring in a typical static joint; the standard dimensions provide a minimum squeeze of 0.022 in. This means that any appreciable scuffing or abrasion of the O-ring when being installed in a static or a moving joint may prevent the ring from sealing. Seals must be stored and installed carefully according to the manufacturer's recommendations. Compatibility of seal and fluid is an important factor. Table II shows what combinations are safe.

Whenever any doubt exists as to compatibility, the seal material and fluid should be tested either in the laboratory or under actual service conditions.

TABLE II—Packing Recommended for Hydraulic Fluids

SEAL COMPOSITION	FLUID TYPE			
	OIL	FIRE RESISTANT FLUIDS		
		PHOSPHATE ESTER	WATER GLYCOL	WATER-OIL EMULSIONS
Neoprene	Yes	No	Yes	S.C.
Buna N	Yes	No	Yes	S.C.
Leather	Yes	No	No	S.C.
Butyl Rubber	No	Yes	Yes	No
PTFE	Yes[1]	Yes[1]	Yes[1]	Yes[1]
Silicone Compound	Yes[1]	Yes[1]	No	No

(1) Mechanical factors must be studied
S.C. = Special Consideration Required

REFERENCE:

Reducing Leakage from Hydraulic Systems by R. Q. Sharpe, Socony Mobil Oil Co, Inc. Published in Lubrication Engineering January 1960, p. 12.

From: ASME paper

7 RELIEF VALVES for PORTABLE EQUIPMENT

Operating characteristics of simple poppet, differential and pilot-operated valves, plus a brief analysis of differential-valve seating.

C. A. L. RUHL
Chief Engineer, New York Air Brake Co.

Relief-valve requirements vary considerably in their applications. In agricultural machinery, for example, a relief valve is used only intermittently for short periods on relatively low-volume systems; for many lift-truck applications there is need for relief valves that have low leakage and pressure build-up. For road-building equipment considerable flow is often diverted over the relief valve.

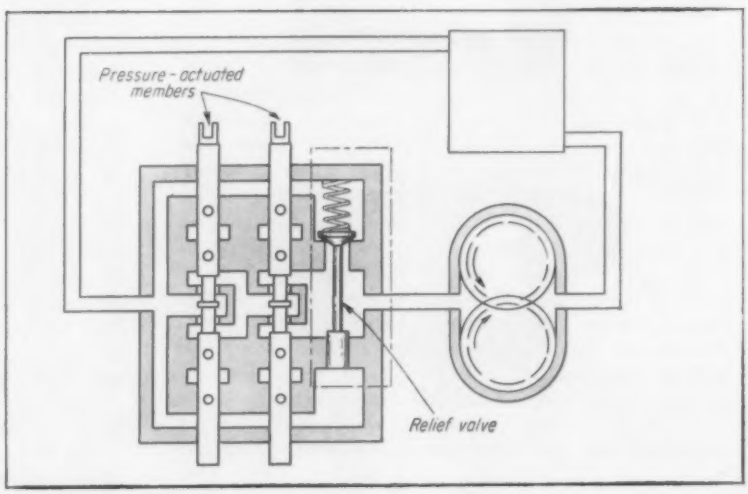
BASIC TYPES

Three basic types of relief valves are described here along with a brief analysis of differential-valve seating.

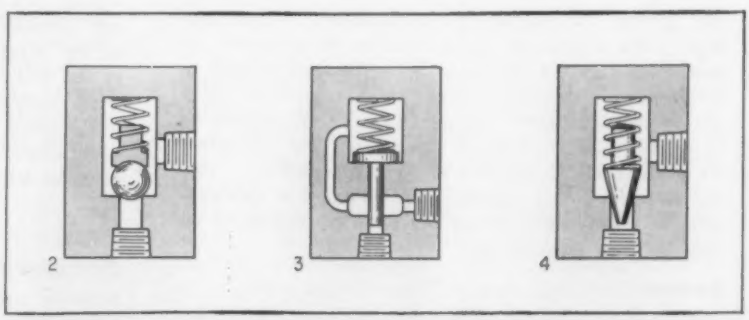
POPPET VALVES

Fig. 1 illustrates a simple mobile hydraulic circuit and shows the relief valve in relation to the other components. In this circuit, the relief valve is used as a pressure limiting device; its function being to protect the other hydraulic components in the circuit, and the structure of the apparatus being operated from forces in excess of those for which they were designed.

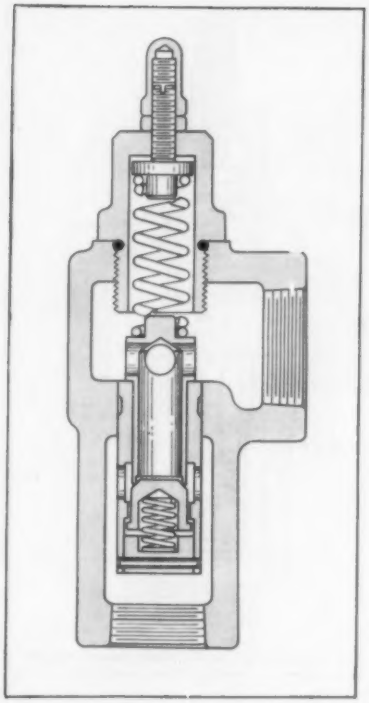
The operating prerequisites for an ideal relief valve are: Zero buildup in pressure from the time it opens until full flow is directed through it; fast response to opening pressures to reduce pressure peaks; no noise during its relieving operation; insensitive to foreign material in the hydraulic fluid;



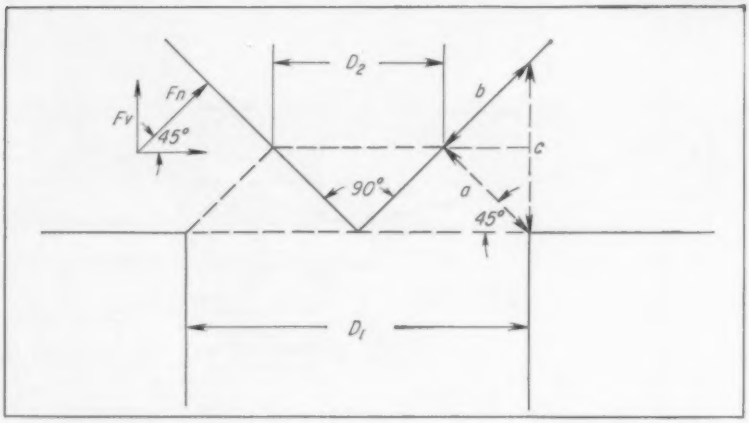
1. HYDRAULIC CIRCUIT with relief valve in relation to other components.



2. SIMPLE POPPET VALVE with ball permits leakage. Similar fault exists in other seat configurations (3) (4) which have basically the same characteristics.



5. DIFFERENTIAL VALVE overcomes some of the faults of simple ball-type valves.



6. VALVE-SEAT configurations affect pressure buildup. Best angle for plunger face seems to be 150°, see Fig. 7.

ability to reseat at the same pressure at which relieved; and to maintain zero leakage until point of cracking.

Relief valves can be and have been designed in varying degrees of complexity. The simplest type of relief valve is the ball type as shown in Fig. 2. In this type of valve, pressure acts on the ball exerting a force which is counteracted by a preloaded spring in the opposite direction.

Theoretically, the ball remains seated until the pressure rises to overcome the preload of the spring, and permits a zero leakage until that time. It is, however, almost impossible to maintain zero leakage; as the pressure increases, the force on the seat decreases. Thus, there is no well-defined cracking pressure with this type of valve.

Owing to the complete unbalance of this type of valve, for high pressures it is necessary to maintain a small seat diameter to keep springs to a reasonable size. As flow increases, a conisderable buildup in pressure occurs. If, on the other hand, the seat diameter and spring force are increased, there exists an increased tendency to chatter—as the ball lifts, the pressure acts momentarily on a smaller area, which in turn decreases the opening force allowing the ball to reseat and the cycle is resumed. Figs. 3, 4 show valves with different configurations but similar characteristics.

Although this type of valve has definite limitations as far as relieving the engine system flow, it does find a use in applications where the flow is quite small. Furthermore, because of its simplicity it is an inexpensive valve to make.

DIFFERENTIAL VALVES

A differential type of valve, Fig. 5, overcomes some of the shortcomings of the simple ball-type valve.

This type of valve is based on the principle of semibalancing a poppet whereby a smaller lifting area, a larger seat diameter and a lighter spring can be employed than a comparable rated simple ball-type valve. Two facets to consider in the design: Maintain a minimum buildup in pressure with increase of flow through the valve; maintain an effective seal at the plunger face.

Valve-seating Calculations

The following example shows how the pressure buildup is affected by the face angle of the poppet.

Conditions: Full Flow (Q), 50 gpm, seat dia (D_1), 0.500 in., area of seat, 0.196 in.^{2}, spring rate, 840 lb/in., pressure at full flow setting (P), 1600 lb/in.^{2}, discharge coefficient (C_d), 0.74, assume zero leakage prior to cracking.

From $Q = C_d A_d \sqrt{2gH}$

Discharge area, $A_d = Q/(C_d \sqrt{2\ g\ \text{Head}}) = 0.0398$ in.^{2}

In Fig. 6 of this discharge area is described by a truncated cone having diameters D_1 and D_2 and side = a, and is given by the following equation:

$$A_d = 1.57\ (a)\ (D_1 + D_2) = 0.025 \text{ in.}$$

From:

$$\frac{0.5\ c}{a} = \cos 45°$$

$$c = 0.354 \text{ in. lift}$$

For the effective area of lift equal to

$$\frac{D^2}{4}$$

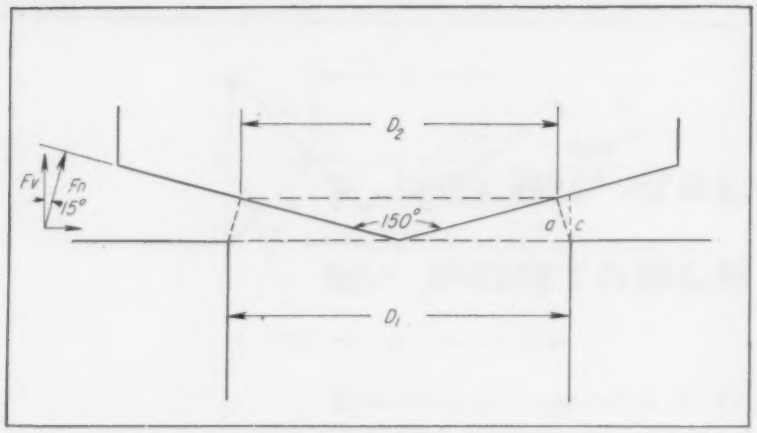
$$D = (D - C)$$
$$= 0.5 - 0.035 = 0.465 \text{ in.}$$
$$\text{Effective area} = (0.785)\ (0.465)^2$$
$$= 0.169 \text{ in.}^2$$

This means that the 1600 psi is acting on the effective area which is equivalent to a force of 271 lb.

To develop this force, the spring has deflected 0.035 in. from its seated position giving a force rise equal to 0.035 in. x 840 lb/in. = 29.5 lb.

Therefore, at theoretical "cracking" the seating force is 271 −30 = 241 or a "cracking pressure" equal to 241/0.196 = 1230 psi.

This shows a buildup of 160 −1230 = 370 psi.



7. POPPET-FACE ANGLE of 150° requires less pressure buildup, but at the expense of less effective seating force.

The valve seat in Fig. 7, with a 150° poppet face has a calculated pressure buildup of 190 psi.

While the pressure buildup for the 150° face is only 190 psi compared to 370 psi for the 90° seat the effective seating force is penalized, the effective seating force being the normal force to the seat face. For the same vertical spring force:

150° face

$F_n = F_v/\cos 15°$

$= 1.04\,F_v$ where F_v is spring force, lb.

90° face

$F_n = F_v/\cos 45° = 1.42\,F_v$

As the relief valve increases in size, it has been found practical to decrease the differential-area to seat-area ratio and increase the spring load to maintain a reasonable unit seating force.

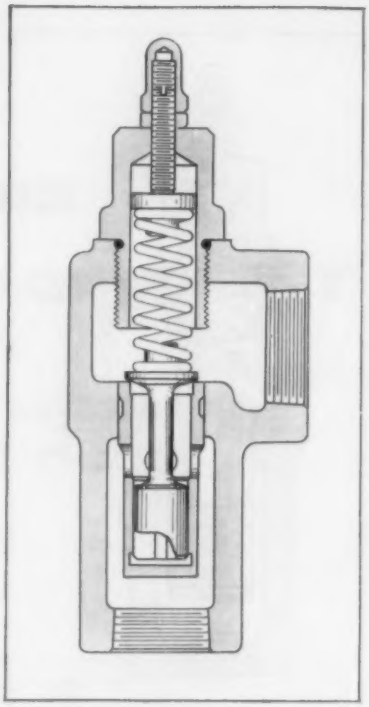
As all the energy of the pressurized fluid that goes by the valve is converted into heat, and as there is no well-defined cracking point for this type of valve, it has been common practice to set the relief valve so that at full-rated flow, the pressure is 25 per cent over the normal working load pressure.

The advantages of this type of valve are: It handles large flows at high pressure without excessive buildup; fast response time in opening; relatively trouble-free operation in contaminated systems.

The primary disadvantage is that a well-defined cracking point is not established, and the buildup is not as flat as can be expected from a pilot-operated type of relief valve.

Fig. 8 shows another type of relief valve known as the inverted differential relief valve. This type of valve also employs a differential area to work against the preloaded spring. By utilizing a moveable poppet, however, the seating force increases with pressure and is maximum at the point of unseating.

The fact that a mass must travel a distance before opening, however, means that shock pressures may occur before the seat and poppet reach the unseating position. After unseating, increased flow affects both types of differential valves in a similar manner.



8. INVERTED DIFFERENTIAL valve has a well-defined opening point.

PILOT-OPERATED VALVE

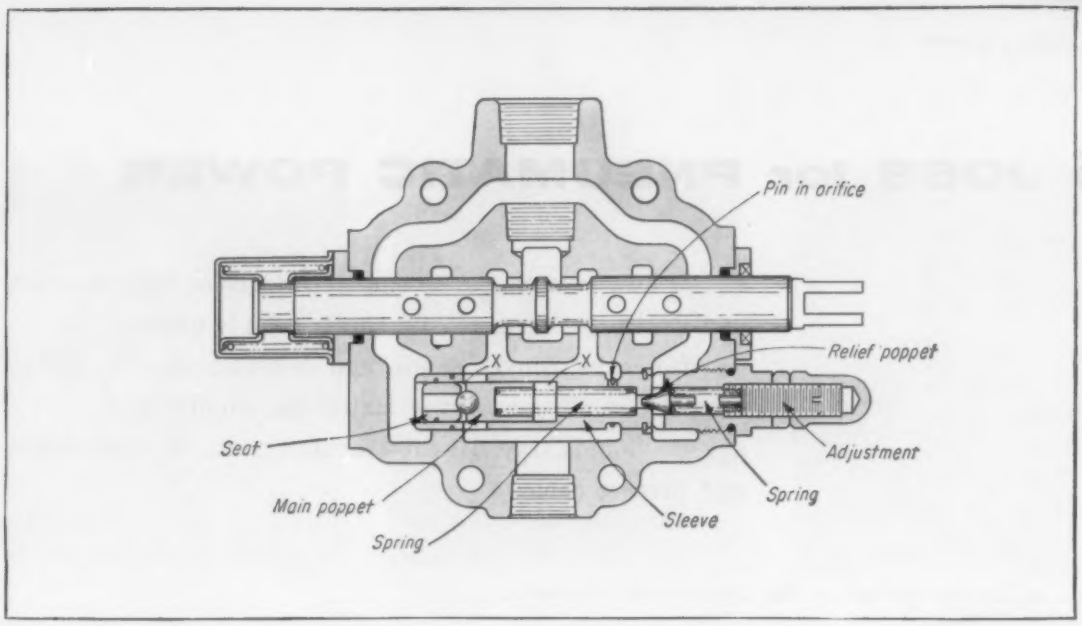
Shown in Fig. 9 is a pilot-operated type of relief valve that is making its appearance in the mobile equipment field, the relief valve being shown as an integral part of a two-spool-directional control valve.

The construction of this particular valve consists of a main poppet, which is urged against seat by a lightly-loaded spring, all which are enclosed in a sleeve. This is fitted into the directional control valve housing such that the ends of the sleeve are exposed to low-pressure areas or return to reservoir passages, while the outside of the sleeve is connected to the high-pressure passage. The space between the seat and main plunger is also exposed to the high-pressure passage through holes in the sleeve. The opposite end of the main plunger is also connected to the high-pressure passage through a small orifice in the sleeve through which is placed a small pin. This pin is free to move in the orifice; its function being to prevent foreign material from clogging the orifice.

At the opposite end from the main poppet seat, a hole in the sleeve serves as a seat for the pilot-relief poppet. The pilot poppet is made to bear against the pilot seat by a spring which is preloaded by adjustment screw.

Operation

The operation of this valve is such that until a pressure is reached whereby pilot poppet opens, a static pressure of the same magnitude exists in chambers X and Y. This pressure causes the main poppet to con-



9. PILOT-OPERATED valve is efficient, but one of the design problems is possibility of unreasonable pressure-surges.

tact the seat with a force equal to the static pressure times the seat opening.

At the time the pilot poppet opens, high-pressure fluid will flow from the outside of the sleeve through the orifice and then through the opening in the end of the sleeve by the poppet, creating a pressure drop between the outside of the sleeve and chamber Y. The plunger will remain closed until a point is reached whereby there is sufficient flow across the orifice to create a sufficient pressure differential between chambers X and Y to move the main plunger from the seat.

The advantages of pilot-operated valves are: Well-defined cracking point; low pressure rise from cracking to full flow; excellent reseating characteristics.

The disadvantages are: Complexity of several moving parts; they demand a clean system for valve to operate; they cost more to manufacture.

APPLICATIONS

The three basic types of relief valves; simple poppet, differential, and pilot operated have been in existence for some time. The use of relief valves in the mobile field vary considerably in their applications—there being a need for each of the basic types.

In the agricultural field, there are many applications where the relief valve is used only intermittently for short durations on relatively low-volume systems.

For many lift-truck applications, and particularly electric lift trucks, power consumption of the hydraulic system has been of paramount importance. Therefore, there is a definite need for relief valves that have very low leakage and pressure buildup characteristics.

For road-building equipment, and particularly for front end loaders, the operation during the digging or bucket-loading cycle represents the longest period of the cycle, and in many cases during breakout, considerable flow is diverted over the relief valve.

One common feature of all mobile applications is the relatively recent trend to high pressure.

In addition to relieving the system flow during a working cycle, relief valves have also been used in closed circuits. These applications utilize the relief valve to relieve inertia loads by dumping cylinder fluid to tank. On applications such as a backhoe, a pair of relief valves have been used on the swing circuit; in which case the fluid is transferred from one cylinder to another of equal size. For these closed circuit applications, in the past, a simple poppet type of valve has been considered satisfactory; but the current thinking is that these relief valves should be able to handle considerably more flow without an excessive pressure buildup. For newer directional control valves, provisions are made so that these overload relief valves may be incorporated in the directional control valve housing and are a pilot-operated type of construction.

REFERENCE:

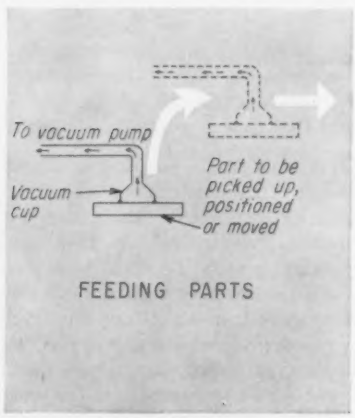
Relief Valves for Mobile Applications by C. A. L. Ruhl, C. E. Control Valves and Vane Pumps, New York Air Brake Co, Kalamazoo Div, Kalamazoo, Mich. Presented at the 1959 ASME Annual Meeting, Atlantic City, N. J. Paper No. 59-A-320.

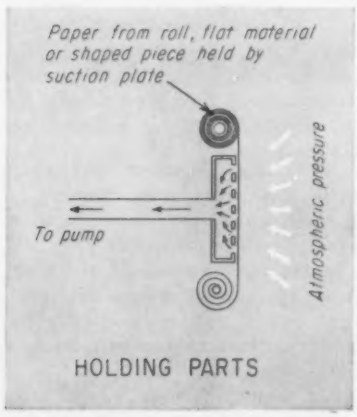
From: Company Booklet

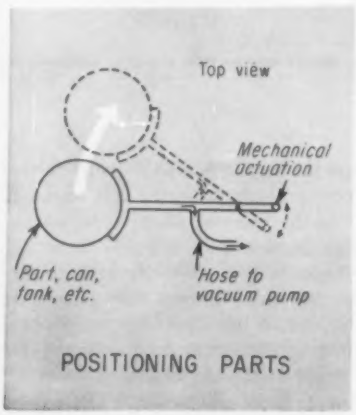
15 JOBS for PNEUMATIC POWER

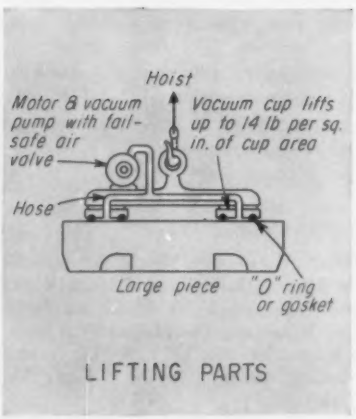
Here's how suction can be employed to feed, hold, position and lift parts, form plastic sheet, sample gases, test for leaks, convey solids, and de-aerate liquids; and compressed air can convey materials, atomize and agitate liquids, speed heat transfer, support combustion and protect cable.

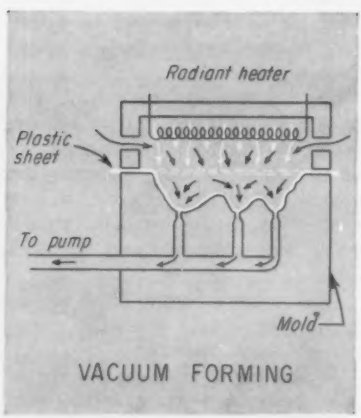
REFERENCE:
Air Motor Applications. Published by Gast Manufacturing Corporation, Benton Harbor, Michigan.

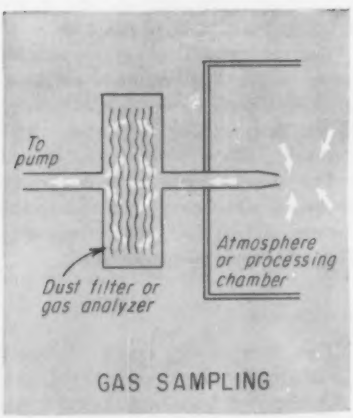




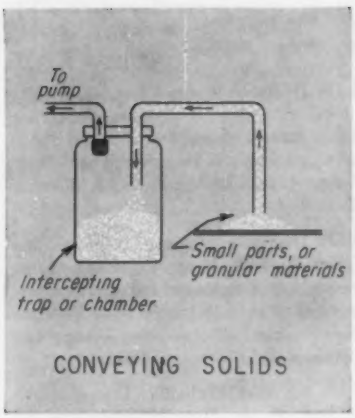



Hoist
Motor & vacuum pump with fail-safe air valve
Vacuum cup lifts up to 14 lb per sq. in. of cup area
Hose
Large piece
"O" ring or gasket
LIFTING PARTS

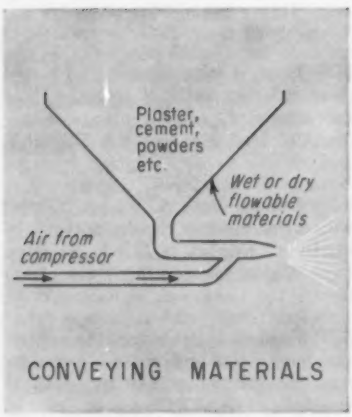


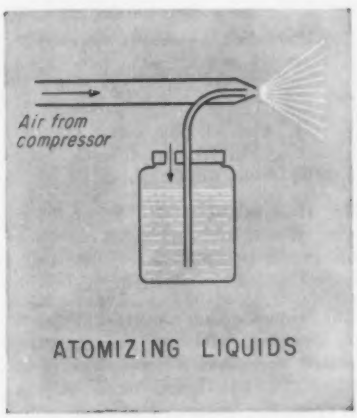


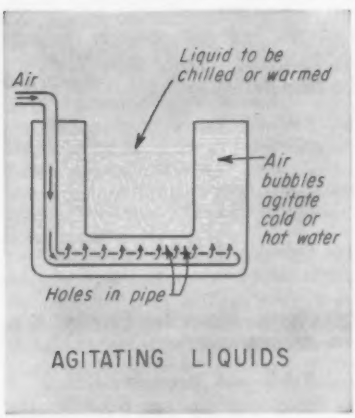
To pump
Part to be tested for fit or flatness
Bubbles if leak exists
LEAK TESTING

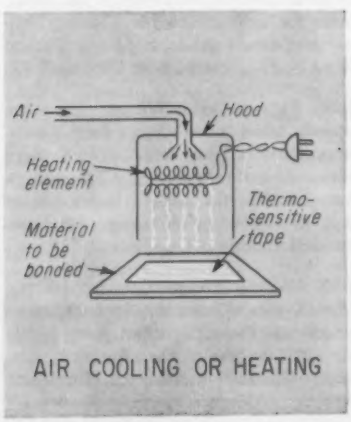

To pump
Small parts, or granular materials
Intercepting trap or chamber
CONVEYING SOLIDS

To pump
Low-vacuum test chambers, tanks, containers, etc.
DE-AERATING HIGH-VISCOSITY LIQUIDS

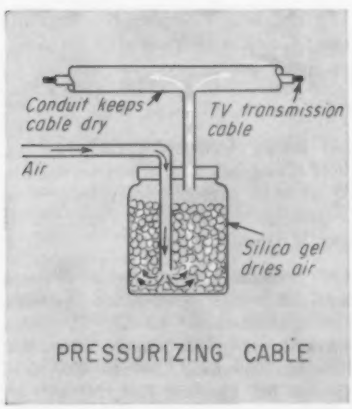

Plaster, cement, powders etc.
Wet or dry flowable materials
Air from compressor
CONVEYING MATERIALS


Air from compressor
ATOMIZING LIQUIDS


Liquid to be chilled or warmed
Air
Air bubbles agitate cold or hot water
Holes in pipe
AGITATING LIQUIDS


Air
Hood
Heating element
Thermo-sensitive tape
Material to be bonded
AIR COOLING OR HEATING

Air
Hotter flame
Gas supply
SUPPORTING COMBUSTION


Conduit keeps cable dry
TV transmission cable
Air
Silica gel dries air
PRESSURIZING CABLE

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(J-1) **Protective Sleeves**—Data folder, 10 pp. Neoprene accordion sleeves protect hydraulic cylinders from dirt, oil, grease and water. Also used on ways, spindles, other exposed parts. A & A Mfg Co, Inc, 712 S 12 St, Milwaukee 4.

(J-2) **Two-way Valves**—Brochure, 8 pp. Describes pilot, solenoid and mechanically operated valves for air, liquid, pressure, vacuum service. Airmatic Valve, Inc, 7313 Associate Ave, Cleveland 9.

(J-3) **Three-way Valves**—Brochure, 12 pp. Describes pilot, solenoid and mechanically operated valves for air, liquid, pressure, vacuum service. Airmatic Valve, Inc, 7313 Associate Ave, Cleveland 9.

(J-4) **Four-way Valves**—Brochure, 8 pp. Describes pilot, solenoid and mechanically operated valves for air, liquid, pressure, vacuum service. Airmatic Valve, Inc, 7313 Associate Ave, Cleveland 9.

(J-5) **Solenoid Valves**—Brochure, 20 pp. Describes two, three, four-way valves for air, oil, water, pressure, vacuum service. Airmatic Valve Inc, 7313 Associate Ave, Cleveland 9.

(J-6) **Cylinders**—Bulletin, 24 pp. Contains specifications for control actuators with air, oil or water to 2500 psi. Bore sizes are ⅜ to 4 in. Airmatic Valve, Inc, 7313 Associate Ave, Cleveland 9.

(J-7) **Valves and Regulators**—Bulletin, 8 pp. Provides specifications and dimensions for pressure regulators, strainers; flow control, sequence and quick exhaust valves for gas and liquid. Airmatic Valve, Inc, 7313 Associate Ave, Cleveland 9.

(J-8) **Hydraulic Components** – Brochure, 4 pp. Contains tables of data for power and hand pumps, cylinders and valves. Rated pressures to 6000 psi. Dynex, Inc, 777 Dynex Dr, Pewaukee, Wisc.

(J-9) **Rotary Actuators**—Catalog, 20 pp. Gives dimensions and ratings for oscillating actuators. Torques range from 30 to 720,000 in lbs. Ex-Cell-O Corp, 945 E Sater St, Greenville, Ohio.

(J-10) **Solenoid Valves**—Provides selection charts of ratings, construction materials, other characteristics for 2-, 3-, 4-way, manual reset, special purpose valves, and strainers. Automatic Switch Co, 5-56 Hanover Rd, Florham Park, NJ.

(J-11) **Hydraulic Pumps**—Catalog, 32 pp. Gives capacities, dimensions, operating curves for gear pumps and motor-pump-valve packages. Wooster Div, Borg-Warner Corp, Old Mansfield Rd, Wooster, Ohio.

(J-12) **Hydraulic Pumps, Motors and Valves**—Bulletin, 36 pp. Provides performance curves, dimensions and specifications. Pressure ratings run from 750 to 3000 psi. Wooster Div, Borg-Warner Corp, Old Mansfield Rd, Wooster, Ohio.

(J-13) **Air and Hydraulic Components**—Catalog, 66 pp. Provides dimensions and capacities of air and hydraulic cylinders, rotary torque actuators and air valves. Carter Controls, Inc, 2800 Bernice Rd, Lansing, Ill.

(J-14) **Hydraulic Components**—Catalog, 72 pp. Describes vertical piston pumps and motors, van pumps and motors plus control valves. Pressure ratings range up to 5000 psi. Also pumping units. Denison Engineering Div, American Brake Shoe Co, 1160 Dublin Rd, Columbus, Ohio.

(J-15) **Hydraulics**—Catalog, 8 pp. Describes rams with 10 to 100 ton capacities; hand and power pumps; accessories. Duff-Norton Co, Box 1889, Pittsburgh 30.

(J-16) **Hydraulic Components**—Bulletin, 4 pp. Describes hand and power pumps, cylinders and valves with rated pressures up to 10,000 psi. Dynex, Inc, 777 Dynex Dr, Pewaukee, Wisc.

(J-17) **Teflon Hose**—Bulletin, 18 pp. Provides dimensioned drawings of hose and fitting assemblies for low temperature environments, transmission of hydraulic fluids or air, and for other service. Anaconda Metal Hose Div, The American Brass Co, 698 S Main St, Waterbury, Conn.

(J-18) **O-rings**—Catalog, 20 pp. List sizes and types of aircraft and industrial o-rings. Materials include natural and synthetic rubbers, elastomers and plastics. The Auburn Mfg Co, Pease Ave & Stack St, Middletown, Conn.

(J-19) **Air Motors, Pumps and Compressors**—Catalog, 8 pp. Shows operating curves and installation drawings. Vacuum pump and other two are based on sliding vane construction. Gast Mfg Corp, Box 117-L, Benton Harbor, Mich.

(J-20) **Uses of Air Motors, Pumps, Compressors**—Bulletin, 12 pp. Explains how products in J-19 have been used in original equipment. Cast Mfg Corp, Box 117-L, Benton Harbor, Mich.

(J-21) **Molded Packings**—Bulletin, 32 pp. Packings of rubber or fabric and rubber are for hydraulics and pneumatics. Dimensions, service recommendations, other design data are given. Greene, Tweed & Co, 320 Elm St, N Wales, Pa.

(J-22) **Tube Fittings**—Catalog, 46 pp. Provides corrosion guide, working pressures, assembly instructions and dimensions of hydraulic butt joint flareless tube fittings. The Imperial Brass Mfg Co, 6300 W Howard St, Chicago 31.

(J-23) **Airborne Hydraulic Pump**—Brochure, 4 pp. Shows construction, dimensions and performance curves for variable displacement pump rated at 3000 psi, 27 gpm. Kellogg Div, American Brake Shoe Co, 97 Humboldt St, Rochester, NY.

(J-24) **Tube Fittings**—Catalog, 117 pp. Furnishes dimensions and drawings of fittings for several types of hydraulic tubing and pipe. Also valves, and tubing tools. The Lenz Co, 3301 Klepinger Rd, Dayton 1, Ohio.

(J-25) **Hose Fittings**—Catalog, 10 pp. Three different kinds of hydraulic hose plus detachable, reusable fittings shown. Lenz Co, 3301 Klepinger Rd, Dayton 1, Ohio.

(J-26) **Blowers**—Bulletin, 6 pp. Three-lobe, rotary positive blowers put out 14 psig for a single stage, 70 psig for three stages. Capacities up to 4000 cfm. M-D Blowers, Inc, 100 Fourth St, Racine, Wisc.

(J-27) **Traps**—Bulletin, 8 pp. Shows operation, temperature and pressure limits for steam, air, gas and gasoline traps. W H Nicholson & Co, 12 Oregon St, Wilkes-Barre, Pa.

(J-28) **Cylinders, Valves**—Bulletin, 36 pp. Contains dimensioned drawings and nomograms for cylinders to 14 in. bore, 2000 psi. Also directional control valves. Pathon Mfg Co, 3823 Pacific Ave, Cincinnati 12.

(J-29) **Fans**—Bulletin, 60 pp. Furnishes capacity tables, other design data, dimensions, construction details. Fans have wheels with airfoils blades. Capacities go over 600,000 cfm. Design is for low or high velocity air conditioning. American-Standard Industrial Div, Detroit 32.

(J-30) **Coolant Pumps**—Catalog, 16 pp. Provides dimensioned drawings, capacities and curves. Includes coolant pump brackets, coolant tanks. The Ruthman Machinery Co, 1809 Reading Rd, Cincinnati, Ohio.

(J-31) Air Cylinder and Valves—Brochure, 8 pp. Shows cylinders with bores to 8 in., air pressures to 250 psi, and the valves to control them. A Schrader's Son, 470 Vanderbilt Ave, NYC.

(J-32) Foot and Check Valves—Bulletin, 6 pp. Construction and sizes of bronze valves and well supplies given. Strataflo Products, Inc, 4939 S Lafayette St, Ft Wayne, Ind.

(J-33) Silicone Hydraulic Fluids—Data folder, 26 pp. Charts and graphs describe properties and operating characteristics of two fluids for high and low temperatures. Silicones Div, Union Carbide Corp, 270 Park Ave, NYC.

(J-34) Pneumatic Products—Catalog, 24 pp. Gives performance characteristics, sample installed arrangements of air line filter, lubricators, pressure regulators. Watts Regulator Co, Lawrence, Mass.

(J-35) Pneumatic Products – Catalog, 22 pp. Presents pressure drop curves, dimensions, ratings, typical installations for air line filters, regulators, lubricators and traps. Watts Regulator Co, Lawrence, Mass.

(J-36) Pumps, Motors, Valves—Catalog, 16 pp. Provides dimensioned drawings, specifications and performance data for components used in lubrication or power systems. Webster Electric Co, 1900 Clark St, Racine, Wisc.

(J-37) Pressure Regulators—Data folder, 23 pp. Shows manual and servo regulators using diaphragms. Inlet pressures up to 6000 psi. Accessory Products Co, 616 W Whittier Blvd, Whittier, Cal.

(J-38) Pneumatic Servovalve—Brochure, 4 pp. Provides dimensions, specifications, operating curves for four-way, torque motor actuated type for driving pneumatic actuators or motors in closed loop servo systems. Raymond Atchley, Inc, 2339 Corner Ave, Los Angeles.

(J-39) Small Bore Cylinders—Catalog, 12 pp. Cylinders with bores from ⅜ to 2 in. are for air, oil, water or vacuum service. They take 150 psi air pressure, 2000 psi hydraulic pressure. The Airoyal Mfg Co, 1990 Springfield Ave, Maplewood, NJ.

(J-40) Liquid Processing Equipment – Catalog, 23 pp. Presents illustrations and specifications of filters, mixers, pumps and tanks for general use and special units for specific applications. Alsop Engineering Corp, Milldale, Conn.

(J-41) Hydraulic Accumulators – Bulletin, 6 pp. Piston type accumulators come in 1 pt to 10 gal sizes, operate at 2000, 3000 and 5000 psi. American Bosch Div, American Bosch Arma Corp, 3664 Main St, Springfield, Mass.

(J-42) Airborne Hydraulic Pump – Brochure, 4 pp. Two-stage, axial piston pump delivers 16 gpm at 3000 psi. Other pumps put out up to 5000 psi. American Brake Shoe Co, 530 Fifth Ave, NYC.

(J-43) Coolant Pumps—Catalog, 16 pp. Provides dimensions, performance curves for motor driven pumps with capacities to 400 gpm. The Ruthman Machinery Co, 1819 Reading Rd, Cincinnati 2.

(J-44) Hp Air Bottles—Brochure, 4 pp. Describes epoxy resin impregnated, glass filament wound spherical bottle with a working pressure of 3000 psi. Apex Reinforced Plastics Div, Washington & Elm Sts, Cleveland 13.

(J-45) Air Line Lubricators—Bulletin, 4 pp. Describes compressed air filters and pressure regulators and devices for providing lubrication for pneumatic tools and appliances. Arrow Tools, Inc, 1900 S Kostner Ave, Chicago 23.

(J-46) Filters—Catalog, 8 pp. Describes air, gas and liquid filters; and for internal combustion engines, breathers, intake silencers, exhaust spark arresters. Air-Maze Corp, 25000 Miles Rd, Cleveland 28.

(J-47) Solenoid Valves—Catalog, 35 pp. Shows direct-lift and pilot operated valves in sizes to 3 in., pressures to 10,000 psi. Atkomatic Valve Co, Inc, 545 W Abbott, Indianapolis, Ind.

(J-48) Pressure Reducers—Catalog, 4 pp. Presents construction details, pressure drop and flow rate table for pilot operated pressure reducing valve for liquid or gas. Atlas Valve Co, 280 South St, Newark 5, NJ.

(J-49) High Pressure Equipment—Catalog, 157 pp. Describes valves, fittings, pumps, pressure vessels, stirred autoclaves for chemical research and high pressure hydraulics. Also includes high pressure compressors. Autoclave Engineers Sales Corp, 2930 W 22 St, Erie, Pa.

(J-50) Piping Ball Joints—Bulletin, 8 pp. Provides several sample piping layouts where ball joints allow expansion and contraction. Barco Mfg Co, 527 Hough St, Barrington, Ill.

(J-51) Air Valves—Catalog, 80 pp. Provides dimensions and ratings for manual, foot operated and solenoid three-way, four-way and shutoff valves for zero to 250 psi. Barksdale Valves, 5125 Alcoa Ave, Los Angeles.

(J-52) Centrifugal Pumps—Brochure, 8 pp. Describes motor driven pumps for corrosive liquids. Capacities range from 1 to 80 gpm. Bart Laboratories & Design, Inc, 135 Manchester Pl, Newark 4, NJ.

(J-53) Control Valves—Catalog, 8 pp. Describes solenoid, solenoid piloted, manual, manifold mounted and other types. Capacities: air to 150 psi; hydraulic to 2000 psi. Beckett-Harcum Co, 985 W Locust, Wilmington, Ohio.

(J-54) Air and Hydraulic Cylinders—Three bulletins, 18 pp. Gives bore, stroke and other dimensions for three series: 200 psi air, 100 psi hydraulic, 1800 psi hydraulic. Also includes parts breakdown. Bendix-Westinghouse Automotive Air Brake Co, 901 Cleveland St, Elyria, Ohio.

(J-55) Hydraulic Components—Bulletin, 4 pp. Provides specifications for jacks, cylinders, pumps and accessories. Blackhawk Mfg Co, 5325 W Rogers, Milwaukee, Wisc.

(J-56) Proportioning Pumps—Bulletin, 8 pp. Describes rotary, positive displacement, variable capacity pumps for controlled flow or blending. Pressures to 125 psi. capacities to 500 gpm. Blackmer Pump Co, 1809 Century Ave SW, Grand Rapids, Mich.

(J-57) Pumps—Catalog, 40 pp. Gives operating characteristics, dimensions, construction of gear, vane and centrifugal pumps for hydraulics, lubrication, coolant and transfer. Brown & Sharpe Mfg Co, 235 Promenade St, Providence, RI.

(J-58) Cylinders and Couplers—Data folder, 22 pp. Quick disconnect couplers are of industrial, commercial and aircraft types. Cylinders are for air or hydraulics. Some cylinders rated up to 300 psi working pressure. The Bruning Co, 601 S 9, Lincoln, Neb.

(J-59) Pumps for Special Fluids—Data folder, 16 pp. Provides dimensions and operating curves for centrifugal pumps handling rocket fuels and low temperature liquids. J C Carter Co, 671 W 17 St, Costa Mesa, Cal.

(J-60) Gear Pumps—Catalog, 64 pp. Presents specification sheets, formulas, dimensional drawings, performance charts, mounting and piping data on gear pumps and directional control valves. Industrial Products Div, Cessna Aircraft Co, Hutchinson, Kansas.

(J-61) Scraper-wiper Seal—Brochure, 4 pp. Seal protects hydraulic and pneumatic cylinders by cleaning rod of water, dirt and stuck-on contaminants. Sizes listed. Chicago Rawhide Mfg Co, 1301 N Elston Ave, Chicago 22.

(J-62) Fluid Filters—Catalog, 8 pp. Shows sampling of filter materials, cartridges and complete units in a wide range of capacities. Commercial Filters Corp, 2 Main St, Melrose, Mass.

continued

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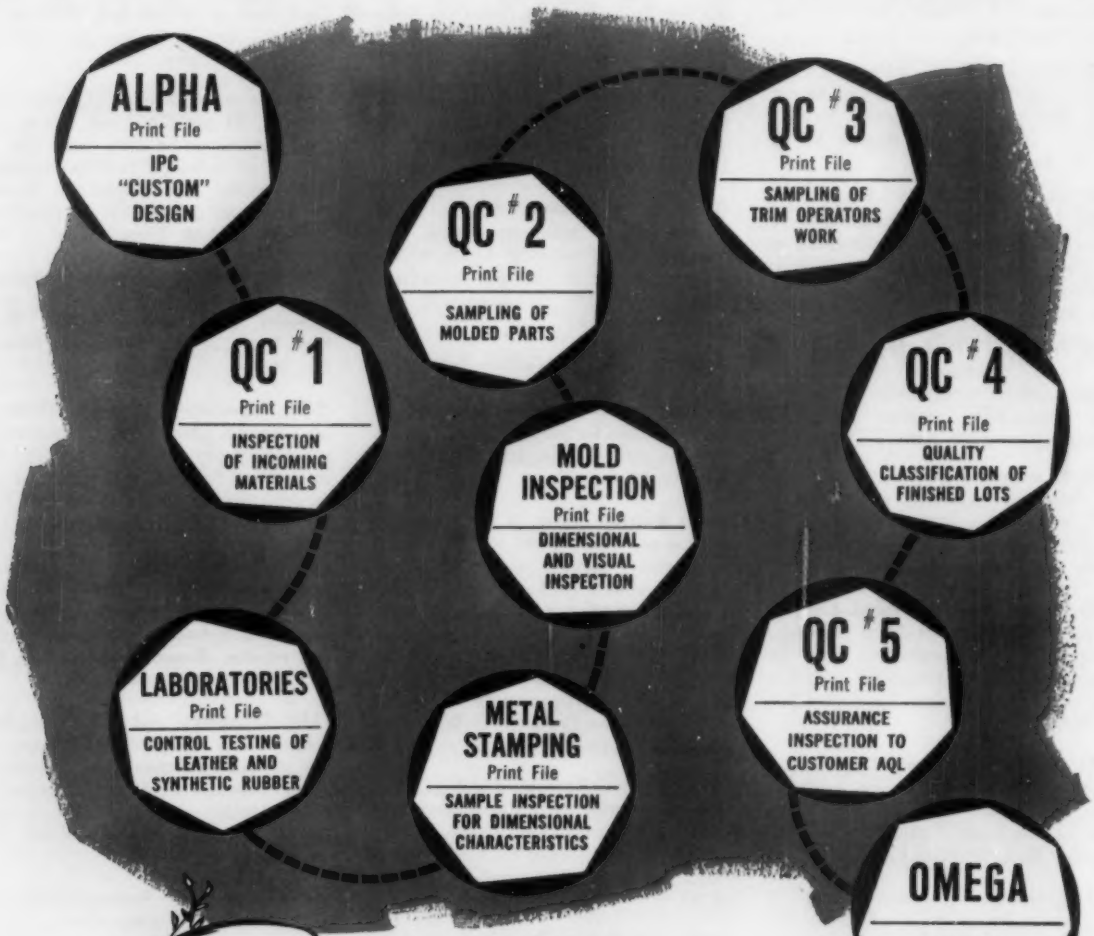

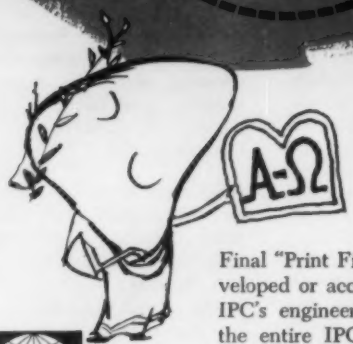

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Final "Print Files" for every product developed or accepted for manufacture by IPC's engineers are located throughout the entire IPC plant. These provide a positive, at-hand reference for product quality!

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Model "H" (Hyd.) Cylinders, 1½" through 8" bores;
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Strokes up to 36", cushioned and non-cushioned.

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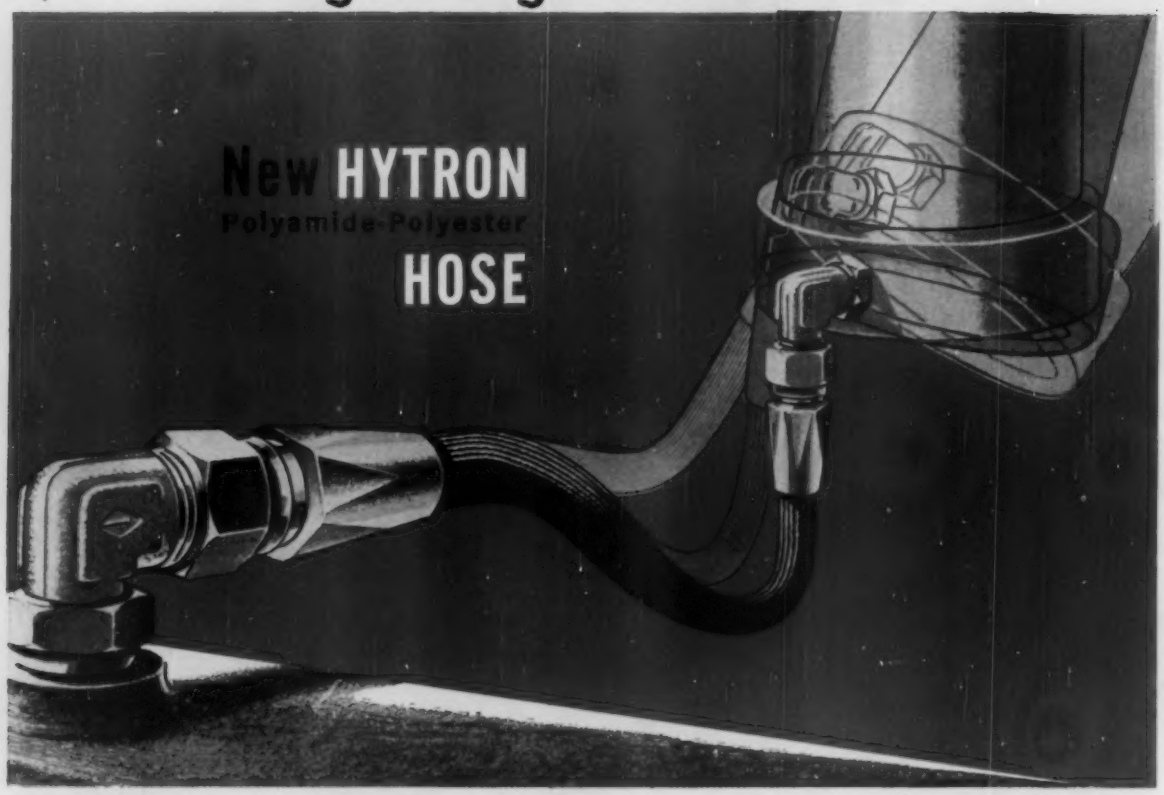

FAR GREATER FLEX-IMPULSE CAPACITY...
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Imperial unveils a completely new concept in pressure hose — opening new opportunities in hydraulic and pneumatic circuitry design, bringing new economies and advantages to thousands of other hose applications.

Hytron was created to solve many of the problems encountered in using S.A.E. types 100R1 and 100R5 hose. It radically reduces hose size and weight, offering smaller O.D. for equivalent pressure capacity and I.D.

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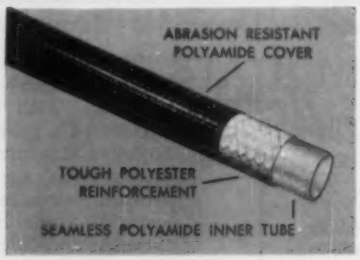
Hytron superiority under punishing flex-impulse conditions has been clearly demonstrated. Comparable 24" lengths of hose with couplings were subjected to cycles from 0 psi to 3500 psi at one-second intervals. Simultaneously they were flexed at 60 times per minute.

After 57.4 hours the S.A.E. 100R5 single wire braid rubber hose burst near a coupling. It took 415.5 hours — *over seven times as long* — before the Hytron hose failed.



Note that there is *no wire braid* in Hytron hose. This eliminates one of the major causes of fatigue failure. Hytron is 80% lighter in weight, and, unlike wire braid rubber hose, retains virtually all of its flexibility under pressure.

Imperial Hytron hose operates in a burst pressure range from 9000 to 12,000 psi, depending on size and temperature. It is recommended for continuous service with fluids from −40 to 225°F, and for intermittent service to 250°F. Hytron is unaffected by nonflammable hydraulic fluids up to 180°F and flammable fluids up to 225°F.

Hytron hose is available in exceptionally long lengths. Furnished as factory-made assemblies, or with easy-to-install reusable couplings. Hytron couplings are of a new design that greatly minimizes flow restriction, offering up to 157% greater flow capacity.

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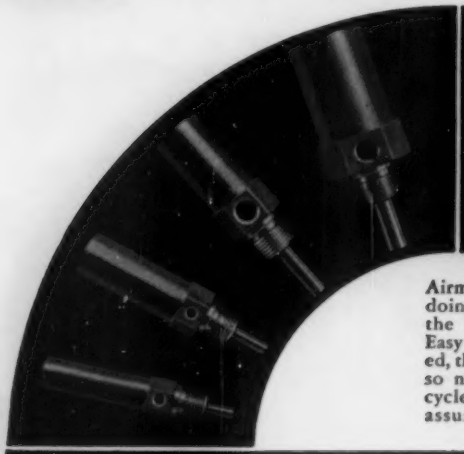

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Airmatic Cylinders and Valves are doing more and more to guarantee the most dependable Automation. Easy to operate, yet compactly designed, they have the inherent ruggedness so necessary for grueling operating cycles. Available from stock, they assure minimum maintenance and lowest service cost. And an Airmatic Engineer is as near as the telephone to help in the selection of the right valve or cylinder for the specific application. Shown on this page are just a few of the hundreds of standard Airmatic units available for your selection.

2-Way
3-Way
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CAM • FLOW • FOOT • HAND • INTERLOCK • PILOT • SEQUENCE • SOLENOID • TIME DELAY

2-Way Pilot Operated ¼" - 3"

2-Way Direct Solenoid ¼" - 2"

2-Way Cam Controlled ¼" - 2"

3-Way Pilot Operated ⅛" - 1"

3-Way Cam Controlled ⅛" - 1"

3-Way Direct Solenoid ⅛" - 1"

3-Way Sequence Time-Delay ¼" - ¾"

3-Way Solenoid Pilot ¼" - 1"

Pressure Regulator

Pipeline Strainer

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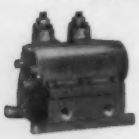

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Base mounted with integral flow controls.
Standard pipe sizes: ⅛", ⅜", ½", ¾"

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Practically a complete hydraulic system in itself, this Roper custom job is a unit for a platform leveler. The design includes pump, check valve, relief valve, and connection for solenoid lowering valve as well as cylinder and tank connections. This is but one of the many examples of custom work Roper does to match its customers needs and/or specifications. Our staff is ready to work with you at any time. Roper Standard Pumps are shown below.

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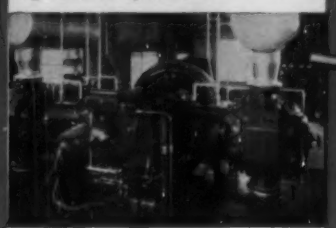
Typical use of Series T on test stand for scavenging and transfer operation.

COMPACT, INTEGRAL PUMP & MOTOR UNITS

"All-in-one" units with pump serving as end bell of motor. Require minimum space and are easily installed . . . no coupling required . . . mount in any position. Choice of 192 models. Each unit is approximately same size as NEMA motor of HP required for driving. Open drip proof or totally enclosed motors; single or three phase as required. .3 to 55 GPM at rated maximum pressure.

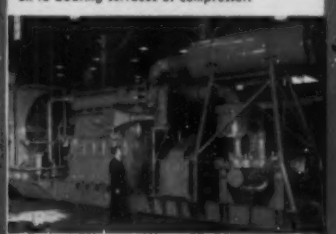


SERIES F

Series F used as before and after pump to supply oil to bearing surfaces of compressor.

FEATURE 4-PORT DESIGN

Feature helical steel pumping gears, hardened steel shafts, bronze flange-type bearings. Have 4-port design with 8 optional piping arrangements (4 for CW and 4 for CCW rotation) to provide installation flexibility. Supplied with or without built-in relief valve in either mechanical seal or packed box construction. 1 to 300 GPM, to 300 PSI.



SERIES H

Series H used in fuel heating system of 1000 HP pumping rig in Saudi Arabia.

FOR HIGH PRESSURE APPLICATIONS

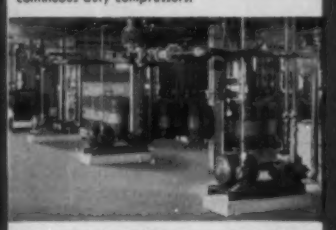
Designed to operate at direct motor speeds. Widely used for all types of hydraulic mechanisms where high pressures are required. Hardened steel spur gears for maximum efficiency, and heavy duty roller bearings and bronze wear plates for long life service. Available with mechanical seal or packed box . . . external relief valve recommended for all installations. 5 to 75 GPM, to 1000 PSI.

SERIES K

Series K furnishes pressure lubrication to these continuous duty compressors.

FEATURES PATENTED VENTURI PRINCIPLE

Extremely compact in all sizes. Helical pumping gears are hardened steel, with steel shafts and bronze bearings. Sizes 10 through 50 GPM have *patented venturi suction and discharge principle* for smooth flow and quiet operation. With or without built-in relief valve; packed box or mechanical seal construction. ¾ to 50 GPM, to 150 PSI.



3600 SERIES

Battery of Series 3600 pumps used in packaging plant of large oil producer and marketer.

FOR GENERAL PURPOSE PUMPING

Designed to handle thick or thin liquids at slow speeds. Operate smoothly and efficiently in either direction, and feature hardened iron pumping gears, hardened steel shafts, and heavy duty bronze sleeve bearings. Furnished with mechanical seal or packed box. Available on steel bedplate, with or without motor, and gear reduction. 40 to 300 GPM, to 100 PSI.

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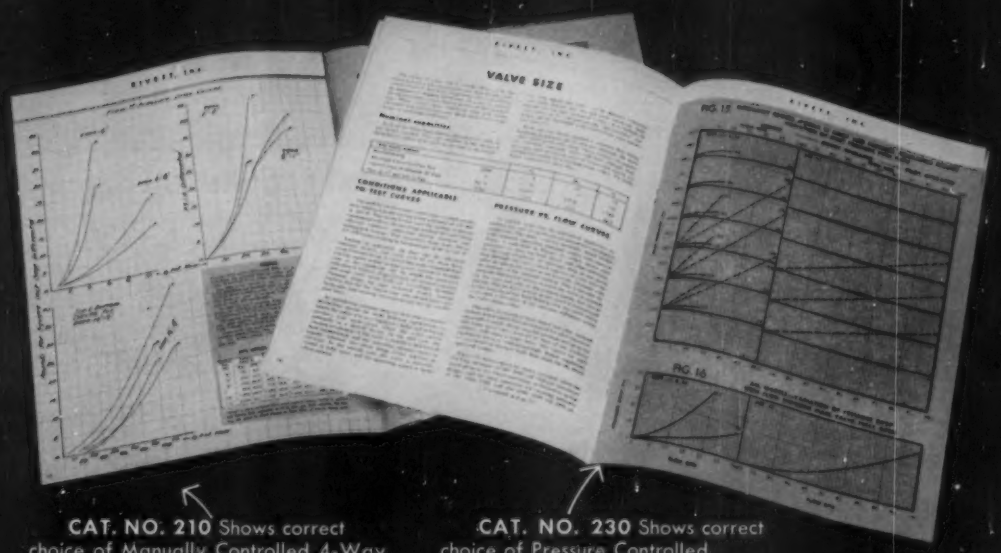

CAT. NO. 210 Shows correct choice of Manually Controlled 4-Way Hydraulic Valves

CAT. NO. 230 Shows correct choice of Pressure Controlled Hydraulic Valves

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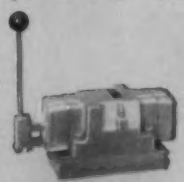
PRESSURE CONTROL
Series 8800: Relief, Sequence, Unloading, Reducing, and Counterbalance. With and without check. See Catalog 230.



MANUAL CONTROL
Series 5000 and 6100: 4-Way. Hand, Foot, or Cam. Sub-plate or Pipe Mounted. ¼" to 2" sizes. 2000 and 3000 P.S.I. See Catalog 210.

SOLENOID CONTROL
Series 6500 and 6600: 4-Way. Direct or Pilot operated. ⅛" to 1½" in three basic sizes. 3000 P.S.I. Low current. See Catalog 261.

PILOT CONTROL
Available in Solenoid, Pressure and Manual operations. ¼" to 1½" sizes. 1500, 2000 and 3000 P.S.I.

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Offers complete high pressure hydraulic circuits

Modern methods with emphasis on progressive engineering have conclusively shown—Dynex circuits are setting the pace to match the high pressure hydraulic power requirements of tomorrow. Flexibility and simplicity designed into each Dynex product help to resolve system design problems involving—space, weight, heat, mechanical efficiency and safety in working pressures. Dynex has repeatedly proven the economy of High Pressure Applications in the Mobile Field. We also hold the solution to many problems that are common to systems operating below 3,000 psi.

CIRCUIT SIZE

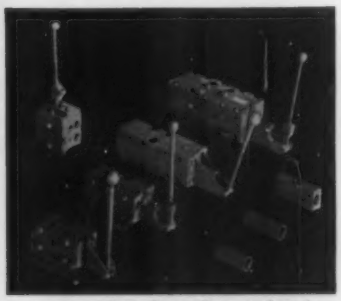
		POWER PUMPS @ 1800 RPM	PRESSURE CONTROL VALVES	DIRECTIONAL CONTROL VALVES	FLUID MOTORS in lbs. torque/100 PSI
1 HP	10,000 PSI	PF 9000 .037 cu. in.* per rev.	VR 9101	VD 4103 (0-3 gpm)	
5 HP	3000 PSI	PF 3003 (2.6 gpm) PF 3006 (4.1 gpm)	VR 9103 VR 3108	VD 4103 (0-3 gpm) VM 6106 (0-8 gpm) VM 6506 (0-10 gpm)	
	4000 PSI	PF 4004 (2.1 gpm)**	VR 9103 VR 3108	VD 4103 (0-3 gpm) VM 6106 (0-8 gpm) VM 6506 (0-10 gpm)	
15 HP	3000 PSI	PF 3008 (5.7 gpm)	VR 3108 VA 3130	VM 6106 (0-8 gpm) VM 6506 (0-10 gpm)	
	6000 PSI	PF 6006 (4.2 gpm)	VR 6108 VA 6130	VM 6106 (0-8 gpm) VM 6506 (0-10 gpm)	
30 HP	3000 PSI	PF 3016 (10.9 gpm)	VA 3130	VM 6520 (0-30 gpm)	
	6000 PSI	PF 6011 (7.9 gpm)	VA 6130	VM 6506 (0-10 gpm) VM 6520 (0-30 gpm)	MF 6011 (12.5)
45 HP	3000 PSI	PF 3021 (14.7 gpm) PV 3021 (0-14.7 gpm)	VA 3130	VM 6520 (0-30 gpm)	MF 3021 (30.3)
	6000 PSI	PF 6015 (10.5 gpm) PV 6015 (0-10.5 gpm)	VA 6130	VM 6520 (0-30 gpm)	MF 6015 (18.2)
90 HP	3000 PSI	PF 3046 (31.4 gpm) PV 3046 (0-31.4 gpm)	VA 3130 VA 6130	VM 6520 (0-30 gpm) (2 bank)	
	6000 PSI	PF 6033 (22.7 gpm) PV 6033 (0-22.7 gpm)	VA 6130	VM 6520 (0-30 gpm)	

COMPLETE LINE OF SINGLE AND DOUBLE ACTING CYLINDERS FOR EVERY APPLICATION

*@ 1725 or 3450 RPM
**@ 1200 RPM

"Split-Flow" is obtainable in all Dynex pumps to give the right volume combination for each phase of a work cycle. Two or more pumps can be replaced by a single "Split-Flow" pump. Write for data on these circuits or components.

Dynex pumps feature "Split-Flow" power for pressures up to 10,000 psi and range from 1 to 90 H.P. or larger.



Dynex complete line of control valves with advanced concepts in design offer greater versatility and system economy.

Dynex now offers a new line of top performance, high quality cylinders with precision bores, chrome rods and wipers.

Dynex power units offer pressures up to 10,000 psi featuring "Split-Flow" pumps to give time saving custom performance.

DYNEX INC.

777 DYNEX DRIVE PEWAUKEE, WISCONSIN

CIRCLE 517 ON READER SERVICE CARD 517

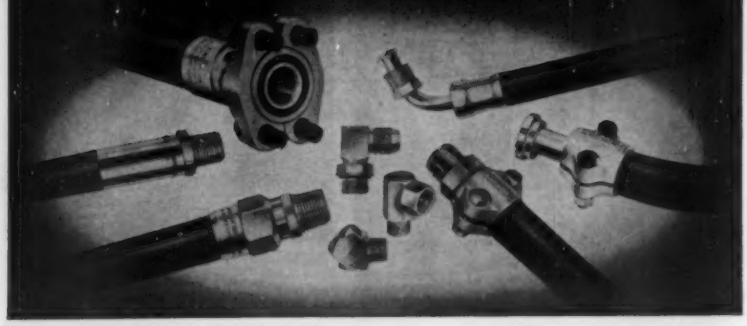
ANCHOR®...THE PLEDGE OF PERFORMANCE

IN HYDRAULIC TRANSMISSION LINES

Failure in a fluid power transmission line is usually costly, with expensive equipment down, production delays and idle manpower until repairs can be made.

To hold such breakdowns to a minimum, Anchor has not only established rigid quality standards to which all Anchor Hydraulic Hose Assemblies must conform, but makes frequent tests and inspections of materials and workmanship to ensure conformity to these high standards.

Because of this, the Anchor emblem on any piece of hydraulic equipment is a real "pledge of performance" and service.



Andy Anchor says:

Send for catalog describing the complete Anchor line.

ANCHOR HOSE ASSEMBLIES with ANCHOR Pressed-On Couplings are available for high, medium and low pressure service with maximum working pressures ranging from 12,500 PSI for 3/16" I.D. 6 Ply Super Spiral Hose to 100 PSI for 2" I.D. Spiral Wire Suction Hose.

ANCHOR REUSABLE COUPLINGS — Regular or Clamp Type, are available for emergency repair and year-to-year superior performance for high, medium and low pressure service ranging from 5000 PSI for ¼" I.D. 2-Wire Braid Hose to 100 PSI for 2" I.D. Spiral Wire Suction Hose.

ANCHOR 4-BOLT SPLIT-FLANGE "O" RING HEAD COUPLINGS are available in a wide range of sizes for high, medium and lower pressure applications.

ANCHOR ADAPTER UNIONS, PIPE FITTINGS, SAE BOSS TYPE FITTINGS A complete line of Pipe and Tube Fittings, Adapter Unions and SAE Boss Type Fittings are offered in a variety of styles and sizes to satisfy the requirements of any installation.

ANCHOR COUPLING CO. INC.

334 North Fourth Street, Libertyville, Illinois

Branch Plants: Dallas, Tex., Plymouth, Mich.

catalogs and bulletins.....continued

(J-63) **Hydraulic Equipment**—Brochure, 13 pp. Provides dimensions, capacities of piston pumps rated 100 to 5000 psi, rams, hand pumps, flow control valves. Connell Hydraulic Co, Marengo, Ill.

(J-64) **Hydraulic Motors and Pumps**—Brochure, 4 pp. Gives performance curves and data, dimensions of 30 psi, fixed displacement type. The Cornelius Co, 550 39 Ave NE, Minneapolis.

(J-65) **Hydraulic Motors and Pumps**—Bulletin, 4 pp. Provides performance data and installation information for 3000 psi, fixed displacement, aircraft type. The Cornelius Co, 550 39 Ave NE, Minneapolis, Minn.

(J-66) **Gate Valves**—Brochure, 4 pp. Gives dimensions and construction of bronze valves for 200 psi steam or 400 psi non-shock fluids. Crane Co, Industrial Products Group, 4100 S Kedzye, Chicago 32.

(J-67) **Tube Fittings**—Catalog, 44 pp. Fittings use ferrule grip for use with metal, glass or plastic tubing up to 1 in. OD. Crawford Fitting Co, 884 E 140 St, Cleveland 10.

(J-68) **Filters**—Catalog, 20 pp. Describes fiber, porous metal, wirewound and mesh media plus housings. Capacities go up to 15,000 gpm. The Cuno Engineering Corp, 80 S Vine St, Meriden, Conn.

(J-69) **Packing**—Catalog, 30 pp. Presents composition, service conditions for shaft, piston, valve, condenser tube, other packing utilizing rubber and asbestos as the main materials. The Darcoid Co, Inc, 145 Ave of the Americas, NYC.

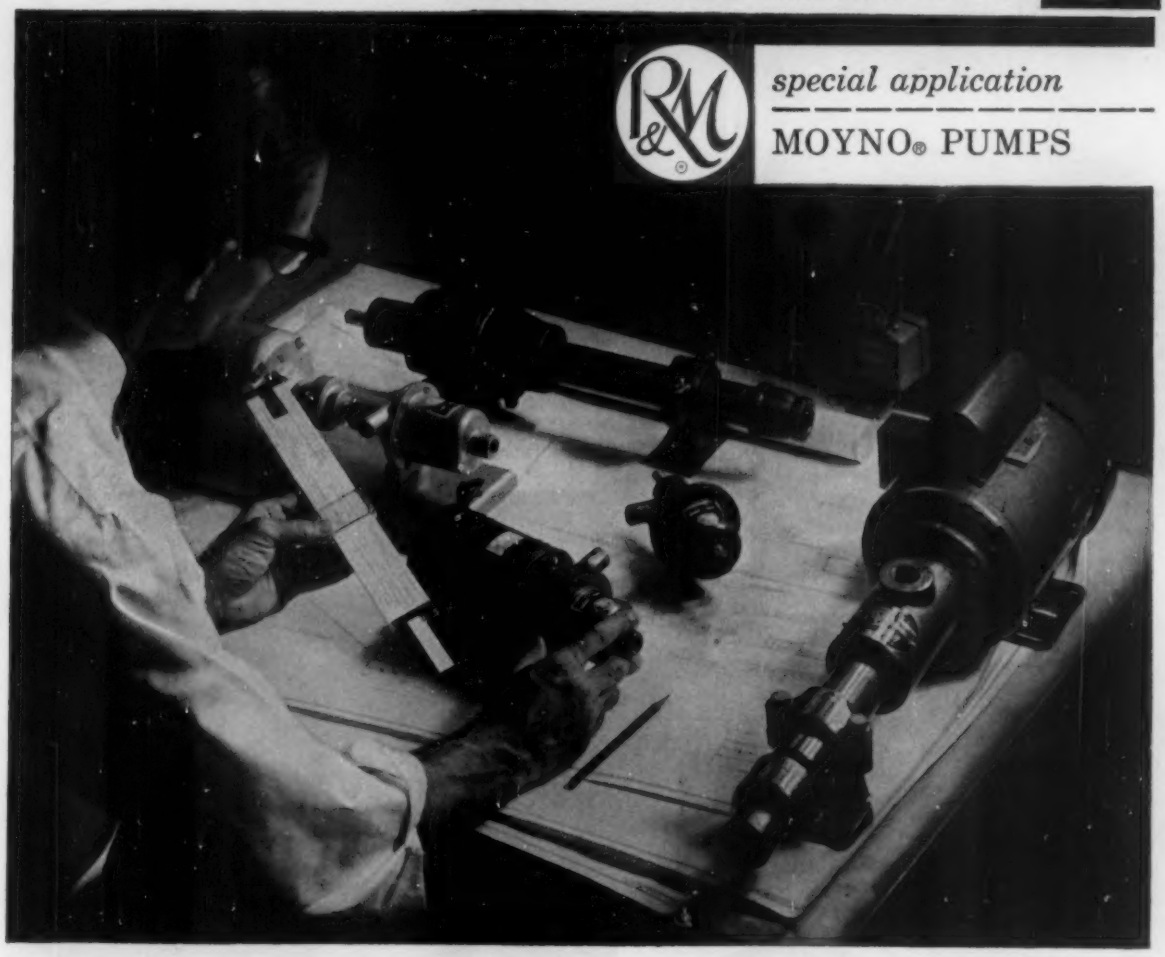
(J-70) **Rotary Gear Pumps**—Bulletin, 28 pp. Contains selection tables, operating curves, dimensions. Pumps handle oils, solvents, chemicals, viscous liquids and others. The Deming Co, Salem, Ohio.

(J-71) **Rotating Unions**—Catalog, 20 pp. Gives engineering data, cutaway drawings, and installation, lubrication and servicing instructions. For water, steam, air, hydraulic, vacuum, coolant service. Deublin Co, 1919 Stanley St, Northbrook, Ill.

(J-72) **Hydraulics Equipment**—Catalog, 200 pp. Contains drawings, specifications, operating data for a comprehensive line. Partial list: relief, bypass, pressure reducing, flow control, check, cam operated, manual, pilot operated, solenoid valves; pumps, power units, hydraulic fuses. Double A Products Co, Manchester, Mich.

(J-73) **Valves**—Catalog, 14 pp. Shows plumbing and heating valves such as flow control, vent, mixing, relief and vacuum types. The Dole Valve Co, 6201 Oakton St, Morton Grove, Ill.

continued

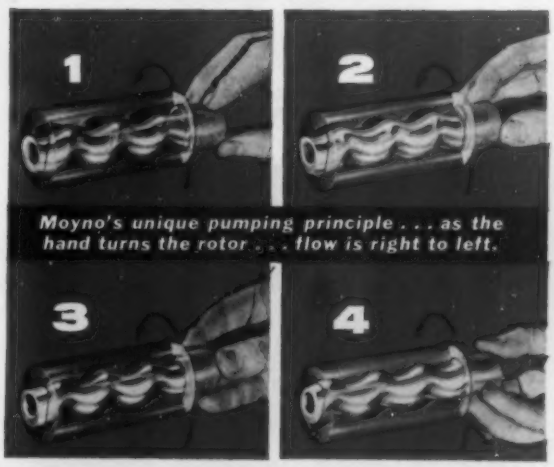


New special application MOYNO® pumps solve many product problems!

Here is a completely new concept in small pumps. These Moynos successfully handle materials ranging from watery liquids and abrasive slurries to large particles in suspension. They use a single moving pumping element . . . have no pistons, valves, high-speed impellers or other quick-wearing parts. Moynos easily handle solids and abrasives that ruin piston pumps. They minimize sealing surface problems common to rotary pumps . . . don't cause foaming and aeration like centrifugal pumps do.

Moyno Special Application Pumps are available in two basic designs, each with or without direct-connected motor, in capacities up to 1200 gph and pressures to 300 psi. If your pumping requirements are so special that custom-designed Moynos are indicated, our engineers will examine your problem and recommend Moynos specifically suited to your needs.

Write today for copy of new Moyno bulletin 55PRE.

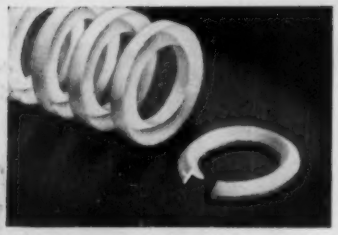


Moyno's unique pumping principle . . . as the hand turns the rotor . . . flow is right to left.

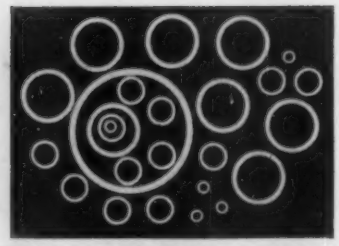
ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

CIRCLE 519 ON READER SERVICE CARD 519



"V" Rings are used as piston or stuffing box seals against reciprocating and oscillating motions



"O" Rings are applied where round-body static or dynamic seals are required

CHEVRON Packings assure positive seal on rams, plungers, reciprocating rods

Teflon-coated cups reduce breakaway friction on inside-packed reciprocating pistons

ENGINEERED TEFLON* PRODUCTS

for Hydraulic-Pneumatic Service

For top efficiency and little downtime, apply Garlock Teflon Packings wherever fluid power is used.

CHEVRON†Packings of solid Teflon—or rubber, coated with Teflon—are as close to "frictionless" as you'll find. First of all, Teflon has the lowest coefficient of friction of any solid material in use today. Moreover, the CHEVRON itself is designed to permit free operation with minimum friction at all pressures. Here's how: with increasing pressures, CHEVRON packing rings tighten to prevent leakage. As pressures decline, the rings instantly ease off, permitting free operation of the rod, ram, or piston without leakage. This exclusive hinge-like construction lengthens packing life and, with proper initial adjustment of the gland, eliminates all further adjustments necessary to compensate for pressure variations. Catalog AD-115.

Teflon "V" Rings for higher pressures. Flexible enough to respond quickly to low gland and fluid pressures due to tapered "V" design.

"O" Ring Packings made of solid Teflon or rubber, coated with Teflon provide exceptional anti-friction qualities on equipment where a round-bodied seal is required. And, a new slotted Teflon ring is available to simplify installation in standard AN grooves. Catalog AD-148.

Teflon-Coated Cups—the first advance in cup design in thirty years. Garlock has perfected a technique whereby cups are coated with a thin layer of Teflon which then becomes an integral part of the cup. Teflon-coated cups reduce breakaway and running friction, and completely eliminate "squealing." Catalog AD-145.

GARLOCK

Other fine advantages of Teflon packings: Solid Teflon is chemically inert, non-flammable, resilient, long wearing. It can be applied against new synthetic hydraulic fluids at temperatures ranging from −100°F to +500°F.

Discuss Garlock Teflon Packings with your local Garlock representative. Call him at the nearest of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada, or write Garlock Inc., Palmyra, N. Y.

Canadian Div.: Garlock of Canada Ltd.

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

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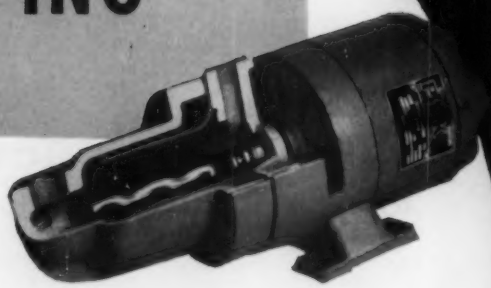
CIRCLE 521 ON READER SERVICE CARD 521

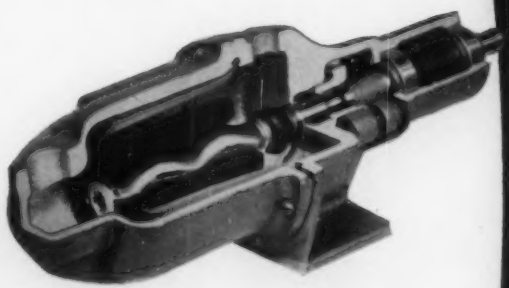
THE ANSWER TO YOUR COOLANT PUMPING PROBLEMS . . . .



MODEL HM

"PRES SURE KOOL PUMPS" — unique in design — use the Moyno principle for positive delivery of coolants at one or more constant pressures, thereby improving work quality, increasing machine output and reducing "down time" of machine tools.

This simple principle of an abrasion resistant helical screw rotor turning in a stator is time-tested and has proven MOST effective for positive displacement in pumping heavily contaminated coolants and cutting oils. "PRES SURE KOOL PUMPS" have exceptional pulling capacity and far exceed other coolant pumps in handling heavy, contaminated fluids, particularly where suction or pressures are demanded.



MODEL HA

Emptying contaminated coolant with "PRES SURE KOOL" mobile unit.

VERSATILE • MOBILE • EFFICIENT

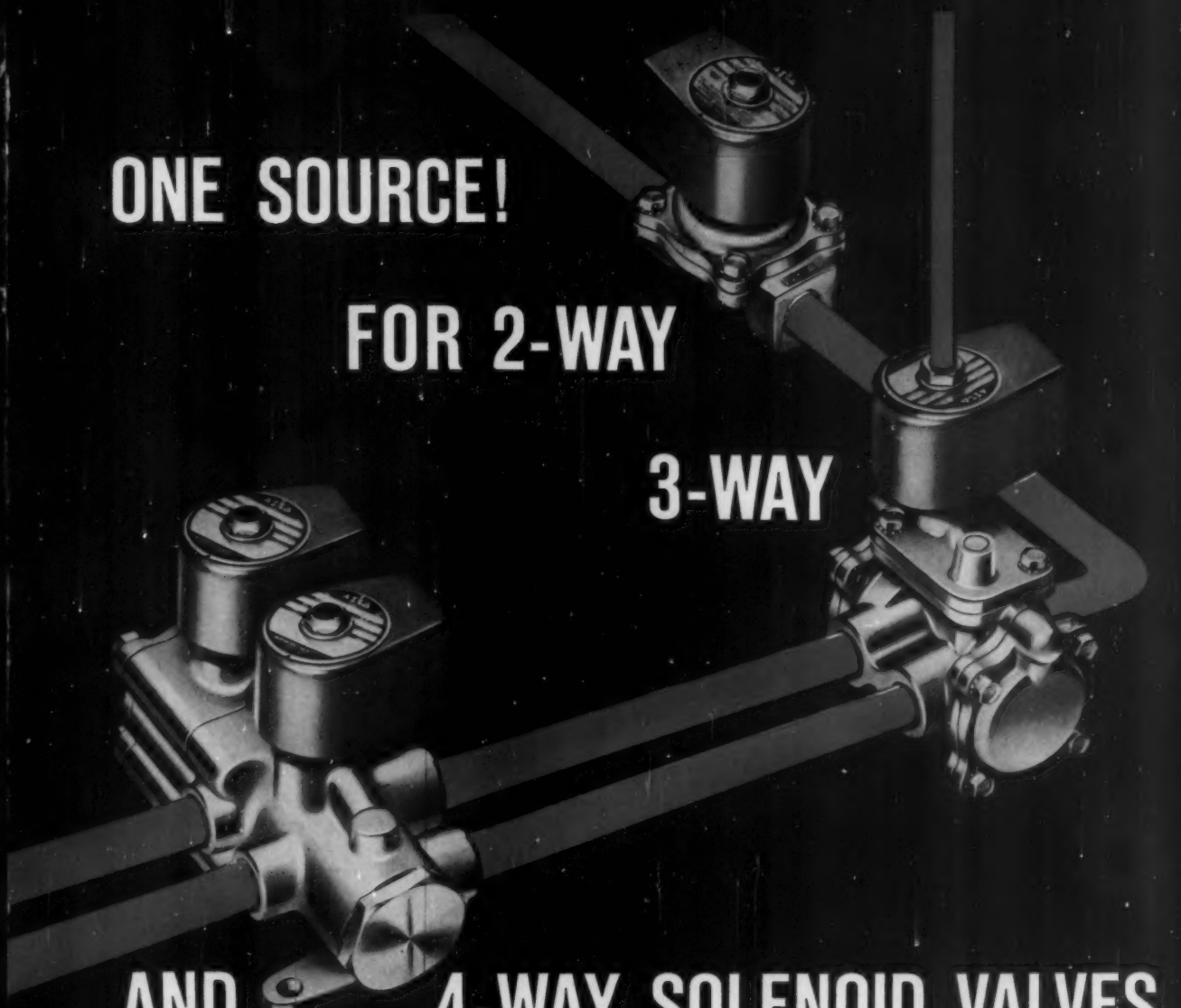
"PRES SURE KOOL PUMPS" — free from turbulence and vibration — can be mounted on a machine either vertically or horizontally with suction line piped to coolant tank. Capacity and pressure capabilities permit many outlets; some under pressure to operate a chuck — direct flow of chips — vertical delivery of coolant, while other outlet pressures may be relieved. Positive action may eliminate manual control and allow pump to operate automatically with tool head movement. Motorless units may be powered by drive shaft or separate motor serving dual function.

SEND US YOUR COOLANT PUMPING PROBLEMS — WE'LL HELP SOLVE THEM.

Descriptive literature upon request.

Associated Engineers Inc.

SPRINGFIELD, MASS. P.O. BOX 1628 • TELEPHONE RE 4-6431



ONE SOURCE! FOR 2-WAY 3-WAY AND 4-WAY SOLENOID VALVES

When you discuss solenoid valve requirements with an ASCO engineer, you benefit from the design and development experience of half a century. The ASCO specialist can recommend the right valve for your needs because ASCO pioneering has brought about the thousands of types of solenoid valves now available:

Two-way valves in pipe sizes from ⅛" to 8"—for temperatures from -350°F to 600°F—for pressures to 5000 p.s.i.

Three-way valves in pipe sizes from ⅛" to 2"—for temperatures from -350°F to 600°F—for pressures to 1000 p.s.i.

Four-way valves in pipe sizes from ¼" to 1½"—for temperatures from -65°F to 212°F—for pressures to 750 p.s.i.—poppet or slide type.

And ASCO can supply you with standard, explosion-proof or water tight enclosures—Class A and Class H coils—a wide range of body materials including cast iron, brass, bronze and stainless steel. Or trade on ASCO experience and have one of our engineers call.

New! Catalog No. 202 covers the ASCO line of Solenoid Valves. Write for your copy today.

For Immediate Delivery...

World's largest stock of Solenoid Valves. A complete Solenoid Valve Stock List will be sent to you with your copy of Catalog No. 202.

Whatever the crucial factor in your flow control applications—reliability, compactness, high cycling rate—there is an ASCO valve that meets your need.

ASCO Valves

ASCO

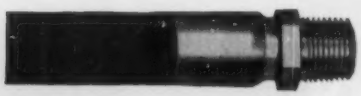
Automatic Switch Co. 54-G HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

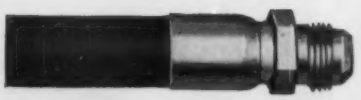
Eastman first to be specified by America's leading OEM's...

A COMPLETE LINE TO CHOOSE FROM FOR YOUR PARTICULAR APPLICATION

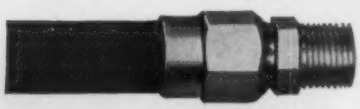
Available in all thread styles and sizes



Permanently Attached Male (NPTF) for 1, 2 and 3 Wire Braid rubber cover hose. Plated to prevent rust and corrosion.
Sizes: ¼" thru 2".
Wkg. Press.: 375—5000 p.s.i.



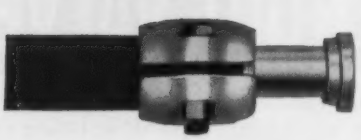
Permanently Attached Male Flare (JIC) for 4 and 6 Spiral Wire Braid rubber cover hose. Used for Ultra High Pressure.
Sizes: ½" thru 1½".
Wkg. Press.: up to 7500 p.s.i.



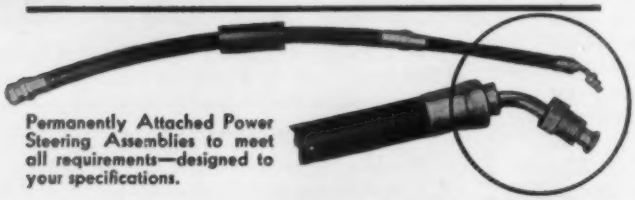
Reusable Male (NPTF) for cotton and rubber cover hose. No skiving necessary.
Sizes: ¼" thru 2".
Wkg. Press.: 350—3000 p.s.i.

Reusable Swivel Female for 1 and 2 Wire Braid rubber cover hose. Easy field replacement.
Sizes: ¼" thru 1¼".
Wkg. Press.: 375—5000 p.s.i.

Permanently Attached Flange Head Couplings for 1 and 2 Wire Braid rubber cover hose. Available in angles to 90°.
Sizes: ½" thru 2".
Wkg. Press.: 375—5000 p.s.i.



Clamp Type Couplings with split flange stems for 1 and 2 Wire Braid rubber cover hose. Exclusive "Inter-Lock" feature.
Sizes: ½" thru 2".
Wkg. Press.: 375—5000 p.s.i.



Permanently Attached Power Steering Assemblies to meet all requirements—designed to your specifications.

Permanently Attached Air Conditioning Assemblies for automotive use—designed to your particular specifications.

It's a known fact that many leading Original Equipment Manufacturers submit their original specifications for their *first* quotation to Eastman.

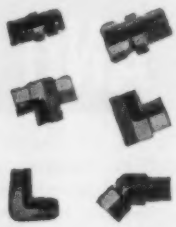
EASTMAN's unequalled experience in hydraulic conversion, plus many original designs shown in a few popular Eastman fittings at the left—give your product an appearance of quality that improves its competitive position. These assemblies are available in all thread styles and sizes.

EASTMAN Engineering Service... Backed by Unequalled Experience

It is also a known fact that Eastman's co-operative engineering counsel and service is highly respected and often requested by leading OEM's. Let Eastman engineers help you lay out your fluid power lines—from pump to point of work—effecting economies in design, improving performance and increasing user satisfaction.

Let EASTMAN recommend the *best assembly . . . for the best performance . . . at the lowest cost.*

Bent Tubing with the necessary fittings to meet your own specific requirements.



Adapters, Adapter Unions and Boss "O" Ring Fittings. All types and sizes available.

FOR ADDITIONAL INFORMATION, WRITE EASTMAN MFG. CO., MANITOWOC, WISCONSIN OR PHONE: MURRAY 4-4495

Eastman *first in the field*

MANUFACTURING COMPANY
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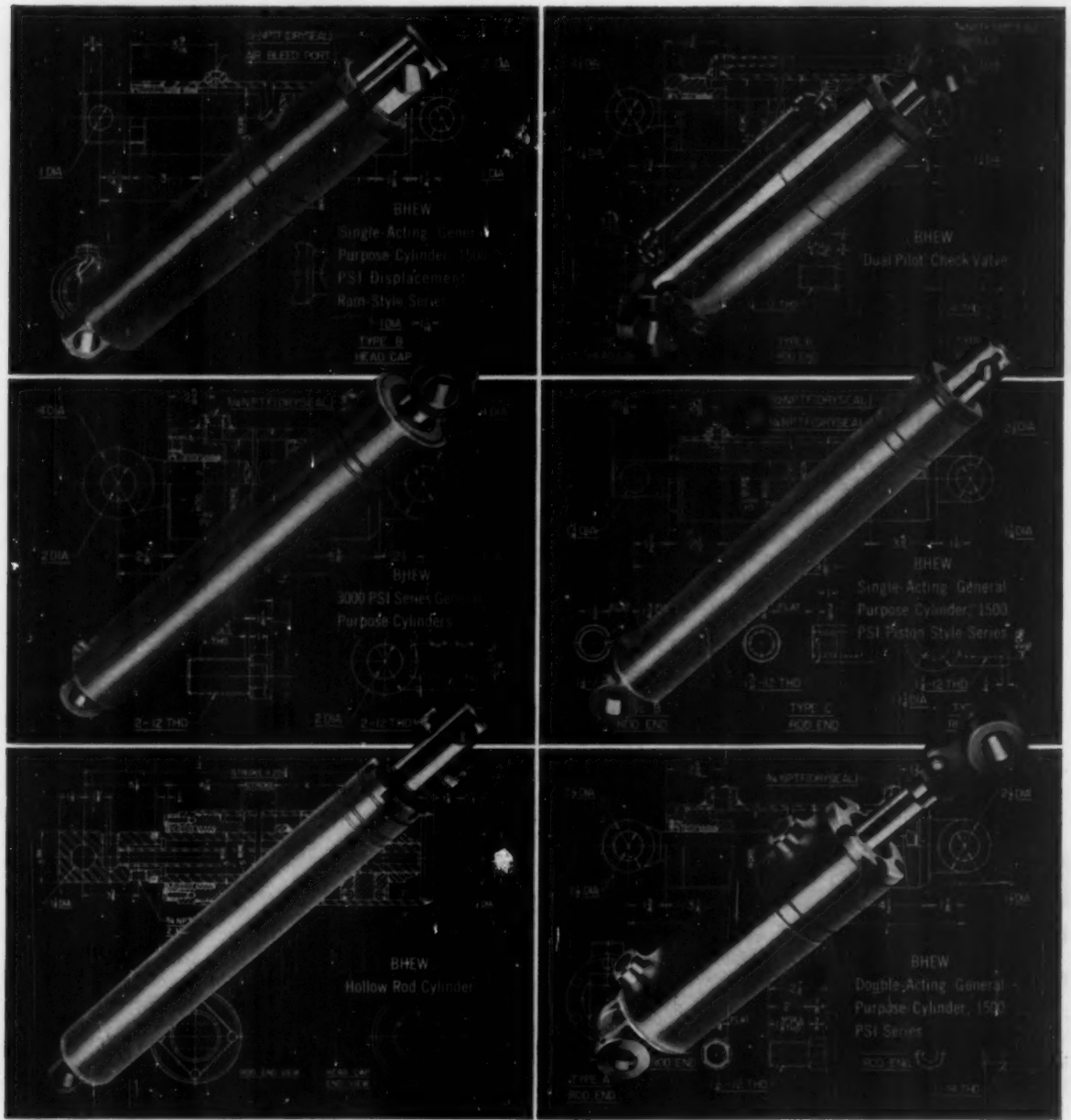
MANITOWOC, WISCONSIN

WRITE for Eastman Technical Bulletins Nos. 100 and 200 on High, Medium and Low Pressure Hydraulic Hose Assemblies.

BHEW HYDRAULIC CYLINDERS

• BASIC DESIGNS • SPECIFIC ADAPTATIONS • SUPERIOR QUALITY • APPLICATION ENGINEERING



Also Manufacturers of "Pressure Operated" Automatic Hydraulic Flow Control Valves.

Let's discuss your design and application problems —

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BENTON HARBOR ENGINEERING WORKS, INC.

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FREE! Write today for Hydraulic Cylinder Engineering Reference Data — 78 dimensional basic designs for general and special purpose double- and single acting cylinders. SAVE TIME.

HIGH PRESSURE PUMPS

Standard and Special

Air driven. For oil or water service. Eight standard models. Other models for lower or higher pressures. Thousands in use with a 12-year record for dependability. Applicable wherever low-volume output at high pressures is the requirement, such as static testing, powering presses, forming, clamping shearing, etc. Complete power packages also available. Send for bulletins.

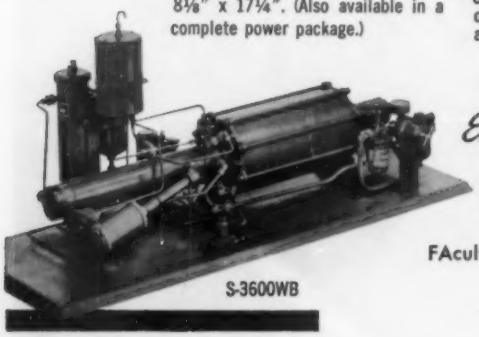
OPERATING CHARACTERISTICS MODEL S-216-C

Model No.	Max. Input Air Pressure	Discharge Pressure at 100 psi Input Air Pressure
S-216-C-10	150 psi	1,100 psi
S-216-C-20	150 psi	1,800 psi
S-216-C-35	150 psi	4,600 psi
S-216-C-60	150 psi	6,600 psi
S-216-C-100	150 psi	8,800 psi
S-216-C-150	150 psi	15,200 psi
S-216-C-200	150 psi	23,750 psi
S-216-C-300	100 psi	33,500 psi

SPECIAL PUMPS—A wide selection of special pumps is also available for various pressures and service. These include ratios down to 1-to-1 and up to 500-to-1, special materials for volatile and corrosive fluids and designs to suit specific working problems. We invite your inquiries relating to special problems.

DE-IONIZED WATER PUMP—Model S-216-S-60: Designed for use with distilled, de-ionized water. Also handles mildly corrosive fluids which must not be contaminated by lube oil of the driving section. Measures 8⅛" x 17¼". (Also available in a complete power package.)

HIGH PRESSURE PNEUMATIC—S-3600WB Power Unit: For nitrogen, air, helium and many other gases. Six air-operated models provide max. output gas pressures from 1000 to 8000 psi. A complete, ready-to-use power package with all necesssary controls. Unit is 25⅜" high, mounted on 22" x 58" platform. (Booster available separately.)


S-3600WB

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Engineering Corporation
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GARDENA, CALIFORNIA
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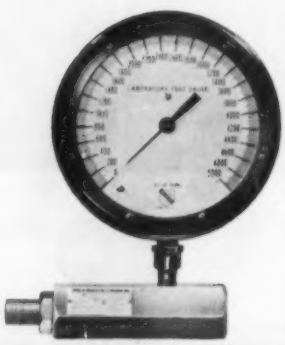
PROTECT EXPENSIVE GAGES

SPRAGUE Model S-214 Series shut off valves automatically cut out gages and other pressure-sensitive instruments when fluid pressures go beyond their operating limits. Automatically open when pressure is again within approx. 80% of set cut-out points. Available for any pressure setting between 10 psi and 10,000 psi. Supplied with standard pipe thread connections, also available with AN tube fittings. Easy to install. Thousands in use.

Write for Bulletin No. 3700.



catalogs and bulletins.....continued

(J-74) **Hydraulic Components**—Catalog, 13 pp. Furnishes dimensions and ratings of pumps, valves, cylinders, hydraulic motors for truck mounted and construction equipment. Wisconsin Hydraulics, Inc, 3165 N 30th St, Milwaukee 16, Wisc.

(J-75) **High Pressure Equipment**—Catalog, 12 pp. Describes such equipment as gas compressors, pressure balances, presses, and others. Some apparatus designed for as high as 150,000 psi. High Pressure Equipment Co, 1222 Linden Ave., Erie Pa.

(J-76) **Plug Valves**—Bulletin, 6 pp. Shows construction and sizes of valve requiring no lubrication. The Duriron Co, Inc, 425 N Findlay St, Dayton, Ohio.

(J-77) **Hydraulic Motors and Pumps**—Bulletin, 12 pp. Pumps and motors are both gear type. Pump pressures to 1500 psi; motors to 1000 psi. Also electric motor and pump combinations. Eastern Industries, Inc, 100 Shiff St, Hamden, Conn.

(J-78) **Chemical Process Pumps**—Catalog, 35 pp. Presents dimensional drawings, performance curves, applications of pumps rated to 10 gpm and 100 psi. Eco Engineering Co, 12 New York Ave, Newark 1, NJ.

(J-79) **Oilers**—Catalog, 12 pp. Lists dimensions of types with lids, self-sealing rubber caps or springloaded balls. Oilers are threaded or press on to tubing. Eynon Dakin Co, 9900 Freeland Ave, Detroit 27.

(J80) **Leather Packings** — Brochure, 57 pp. Provides dimensional standards, extensive design discussion, glossary, applicable tables. Excelsior Leather Washer Mfg Co, Inc, 720-730 Chestnut St, Rockford, Ill.

(J-81) **Lubrication Systems**—Bulletin, 24 pp. Central manual or automatic pumps deliver oil through valves for individual lubrication points. Sample systems shown. Farval Div, Eaton Mfg Co, 3300 E 80 St, Cleveland 4.

(J-82) **Filters**—Data sheets, 28 pp. Presents installation instructions, capacity ratings, friction loss charts for liquid filters. Filtros Inc, 601 W Commercial St, E Rochester, NY.

(J-83) **Hydraulic Tube and Pipe Fittings**—Catalog, 26 pp. Lists sizes of self-flaring, flareless and flare type fittings. Explains how to install, gives specifications. Flodar Corp, 16911 St Clair Ave, Cleveland 10.

(J-84) **Straight Thread Tube Fittings**—Catalog, 20 pp. Lists sizes of fittings such as elbows, tees, connectors. Includes o-rings and tools. Flodar Corp, 16911 St Clair Ave, Cleveland 10.

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Proper selection of constant Hydraulic Pumps for systems

By: Ellis H. Born
Director of Sales-Engineering
Denison Engineering Division
American Brake Shoe Co.
Columbus, Ohio

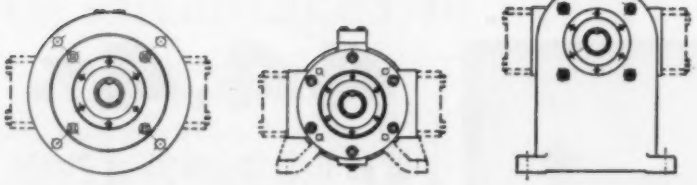
Whether to use a high pressure system or a low pressure system is perhaps the most basic decision the designer faces in developing the proper hydraulic system. This decision involves such factors as efficiency, space requirements and, most important, cost.

SPACE CONSIDERATIONS

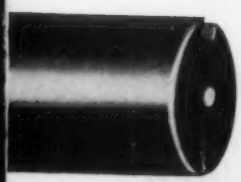
Furnishing fluid horsepower is the function of a hydraulic system. Horsepower yield is determined by multiplying system pressure (psi) times flow rate (gpm) times a constant of 0.000583. Application of this formula reveals that a 5000 psi system develops five times the horsepower of a 1000 psi system at the same rate of flow. Accordingly, the 5000 psi system requires only 20% of the flow rate of a 1000 psi system to produce the same fluid horsepower.

Reduced rate of flow permits designs which incorporate smaller valves, piping, hydraulic cylinders and reservoirs. Since reservoirs are often the largest single fluid component in a system, appreciable space savings can be realized with high pressure systems. If recommended hydraulic practice is followed, reservoir capacity is three times greater than the gpm displacement of the pump. Hence, for the same amount of fluid horsepower, reservoir capacity can be reduced as much as 80% in a high pressure system. The high

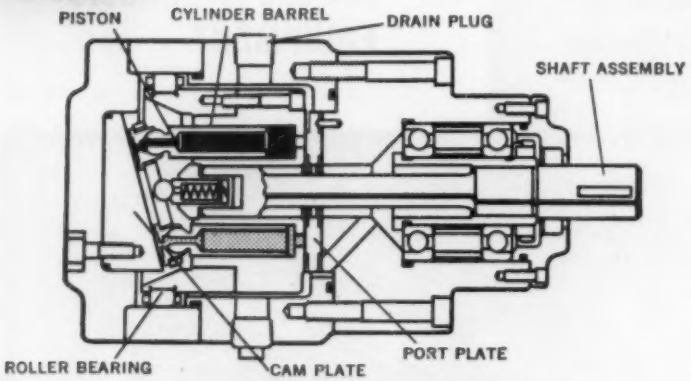
MOUNTINGS



FLANGE **FACE and PEDESTAL** **BRACKET**



Denison constant volume axial piston pumps offer volumes up to 122 gpm, pressures to 5000 psi, at their rated speeds of 1200 and 1800 rpm. Face, flange, bracket or pedestal mountings are available for ready adaptation to your particular installation. Models are available for either clockwise or counter-clockwise rotation.



DETAILS OF CONSTRUCTION

volume Axial Piston up to 5000 psi

pressure system not only allows savings in space through use of smaller components and capacities, but reduces the weight and mass of the hydraulic power package as well.

COST FACTORS

Use of smaller components in high pressure systems not only saves space, but affords worthwhile cost reductions.

Compact system elements cost less and because they are smaller, as well as lighter, assembly is easier and faster. Raw material requirements are also reduced. These advantages permit the over-all hydraulic system design to incorporate less weight and mass. The latter is especially important where portability is concerned.

SYSTEM EFFICIENCY

In any hydraulic system, a part of the generated fluid horsepower is used to force fluids through the system. Resultant line and pressure decreases are far less significant in high pressure systems. For example, a pressure drop of 50 psi represents a loss of 5% in a 1000 psi system, but only a 1% loss in a 5000 psi system. It follows that high pressure systems have an inherent efficiency advantage over low pressure systems.

The ability to provide sustained efficient power for a high pressure system is best fulfilled by a precision-built axial piston pump because of its low slippage rate and operating characteristics.

All internal forces created by hydraulic pressure against the moving parts are counteracted by the use of hydraulic balancing.

Using the principle of hydrostatic balancing eliminates the need for expensive and often cumbersome thrust bearings in the pump. This design minimizes pump size and allows a more compact pump or fluid motor package.

Other advantages are gained through hydrostatically balancing pistons and the cylinder barrel. For example, excessive loading of piston shoes against the cam plate is avoided. In addition, excessive loading of the cylinder barrel against the port plate is prevented, virtually eliminating wear caused by sliding action.

Life expectancy of internal axial piston pump parts is almost infinite since constant lubrication is supplied by system fluid.

Data and specifications on 5000 psi pumps, motors and controls are available from your Denison representative—located in principal cities—to assist you in developing hydraulic systems for maximum efficiency and economy.

NEW CATALOG FOR DESIGNERS AND ENGINEERS

Write for your copy of Bulletin 220—"Hydraulic Power to 5000 psi". Includes complete specifications, operating data and applications for Denison's full line of hydraulic pumps, motors and controls.

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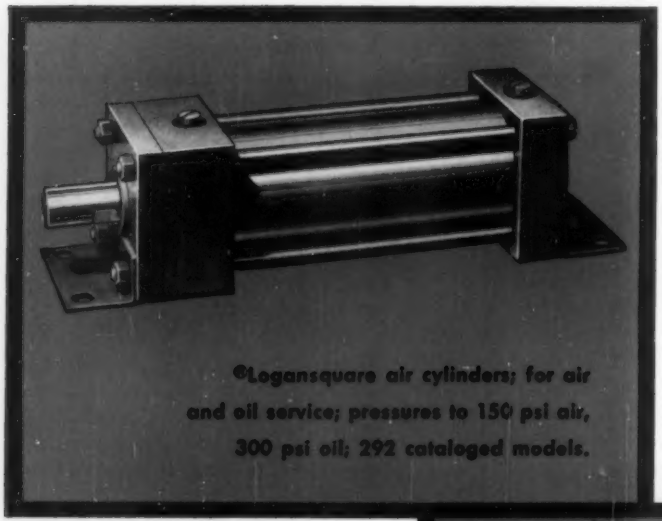

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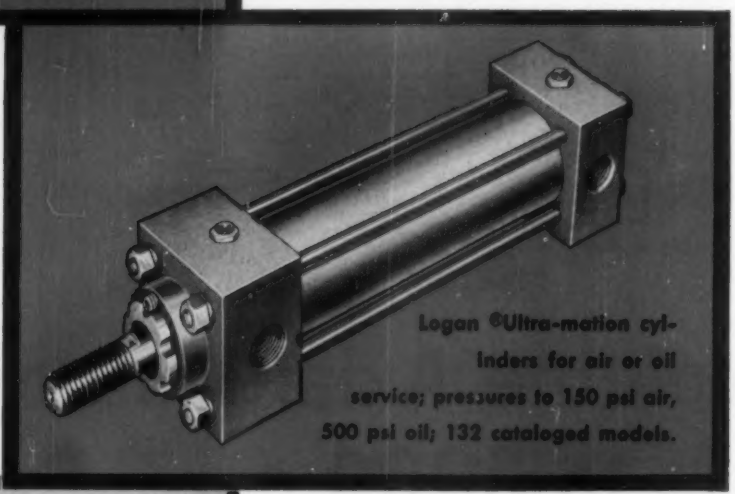

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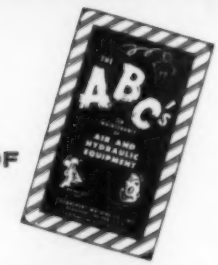


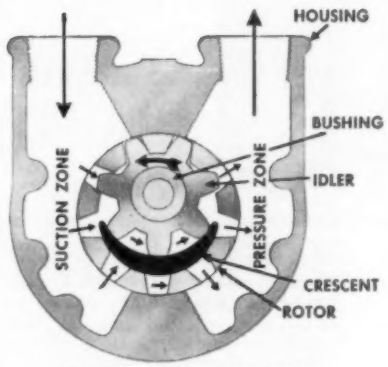
A down-to-earth 20-page booklet on the "rights" and "wrongs" in setting up and servicing air and hydraulic equipment.

MEMBER: National Machine Tool Builders' Assn.; National Fluid Power Assn.

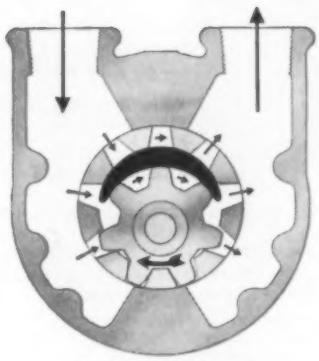
The TUTHILL Internal Gear Pump... and its advantages in reversing applications

by E. H. Schanzlin,
Chief Engr., Tuthill Pump Co.

Extremely high reliability, proven in thousands of applications over a 30 year period, has made Tuthill's internal gear pump an industry standard. The Internal gear construction particularly adapts itself to reversing pump applications as indicated in the sketches at right.



COUNTERCLOCKWISE ROTATION



CLOCKWISE ROTATION

How It Operates

Key elements are the rotor, idler gear and the crescent shaped partition. This crescent shaped partition, shown in heavy black, is cast integral with a moving part called the idler carrier.

In the drawing at left, power is applied in counterclockwise rotation to the rotor and transmitted to the idler gear with which it meshes. The space between the outside diameter of the idler and the rotor is sealed by the crescent. When the pump is started, there is an increase in volume as the teeth come out of mesh. This creates a partial vacuum, drawing the liquid into the pump through the suction port. The liquid fills the spaces between the teeth of the idler and rotor and is carried past the crescent to the pressure side of the pump. When the teeth mesh on the pressure side the liquid is forced from the spaces and out through the discharge port.

When shaft rotation is changed from counterclockwise to clockwise, as in the drawing at right above, the idler carrier, (including the idler gear and crescent) automatically rotates 180° through the suction zone. This changes the directional flow within the pump without changing port positions. The idler carrier rotates in a cover casting fitted with stops so that the crescent can rotate only 180° —always through the suction zone. If rotation were again reversed to counterclockwise, the crescent would swing back to its original position (shown at left above).

No valves required . . . ports remain constant

This unique construction permits positive reversing action, without any valves, and with the port positions remaining constant. In addition Tuthill's reversing pumps provide all the other attributes of internal gear construction . . . extremely high reliability, compactness, and high efficiency.

Reversing Pumps with internal gear construction pay particular dividends on applications where the pump must be driven from a reversing shaft or when machinery must be shipped without knowing the ultimate direction of the driving unit.

375 reversing pump models

Tuthill offers a complete selection of over 800 different pumps including 375 different reversing pump models for capacities from ⅓ to 200 GPM; for pressures to 400 PSI; and speeds to 1800 RPM. These include a complete selection of stripped models for incorporation into products. Specially designed housings, shaft extensions, relief valves and many other features can be developed by Tuthill's engineers to meet the requirements of specific applications.

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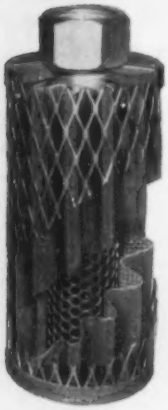
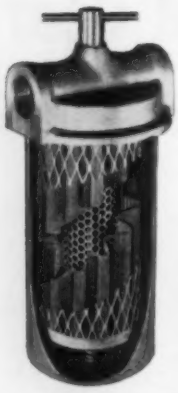


Synclinal SUMP TYPE

CAPACITIES: 5—8—10—20—30—50—75 and 100 G.P.M.
PIPE SIZES: ¾"—1"—1¼"—1½"—2"—2½" and 3".
CONNECTIONS: Coupling—Male Nipple.
BY-PASS VALVE: Not Available.

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants, all types of Fire-resistant Hydraulic Fluids and Water.



Synclinal LINE TYPE

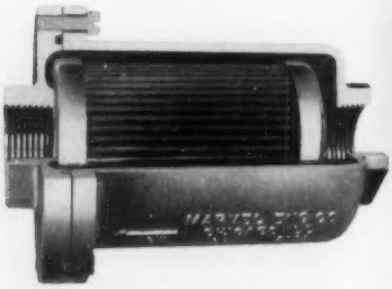
CAPACITIES: 5—8—10—20—30—50—75 and 100 G.P.M
PIPE SIZES: ¾"—1"—1¼"—1½"—2"—2½" and 3"
BY-PASS VALVE: Not available.
OPERATING PRESSURES: Up to 80 p.s.i

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants, all types of Fire-resistant Hydraulic Fluids and Water.

Bonded LINE TYPE

CAPACITIES: 10—20—30—50 and 75 G.P.M
PIPE SIZES: 1"—1¼"—1½"—2" and 2½"
BY-PASS VALVE: Available with or without.
OPERATING PRESSURE: Up to 250 p.s.i.
OPERATING TEMPERATURES up to 300° F

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants, all types of Fire-resistant Hydraulic Fluids



IN-LINE FILTER

CAPACITIES: Up to 60 G.P.M.
PIPE SIZES: ¾"—1"—1¼" and 1½" (at both inlet and outlet).
BY-PASS VALVE: Available with or without By-Pass Valve.

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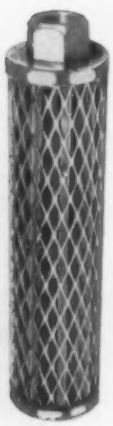

Tandem Synclinal SUMP TYPE

CAPACITIES: 10—16—20—40—60—100—150 and 200 G.P.M.
PIPE SIZES: ¾"—1"—1¼"—1½"—2"—2½" and 3".
CONNECTIONS: Coupling—Male Nipple.
BY-PASS VALVE: Not available.

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants, all types of Fire-resistant Hydraulic Fluids and Water.

Bonded SUMP TYPE

CAPACITIES: 10—20—30—50 and 75 G.P.M.
PIPE SIZES: 1"—1¼"—1½"—2"—and 2½".
CONNECTIONS: Coupling—"O" Ring—Male Nipple.
BY-PASS VALVE: Available with or without By-Pass Valve.

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants and all types of Fire-resistant Hydraulic Fluids.

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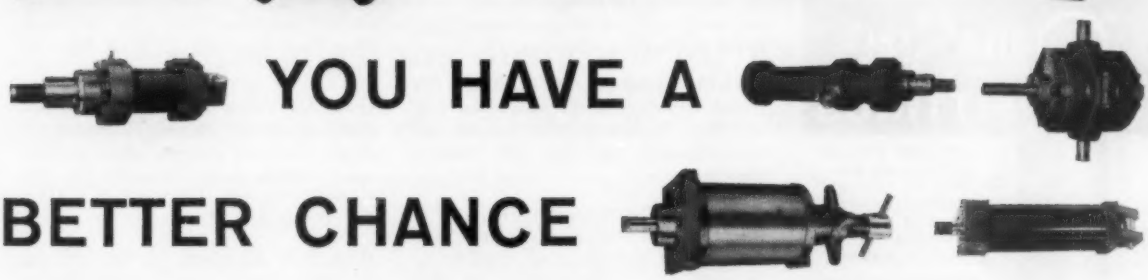

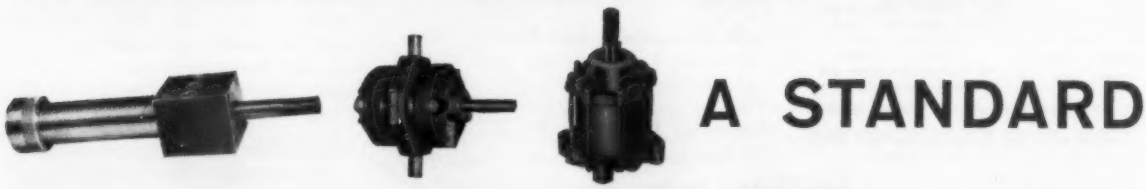

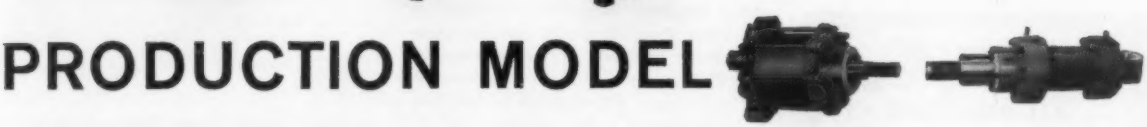

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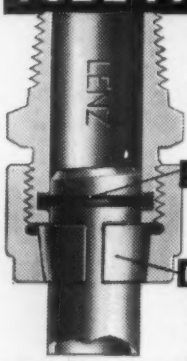

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FORT WAYNE, INDIANA

catalogs and bulletins.....continued

(J-85) Hydraulic Port Fittings—Catalog, 8 pp. Lists sizes of no-swing fittings making metal-to-metal contact. Includes tools and installation instructions. Flodar Corp, 16911 St Clair Ave, Cleveland 10.

(J86) Flow Controls—Catalog, 8 pp. Describes restrictor, needle valves and flow regulators. Ratings to 3000 psi with oil. Flow Controls, Inc, Box 186, Mentor, Ohio.

(J-87) Relief Valves—Catalog, 16 pp. Provides dimensioned drawings, characteristics curves of hydraulic relief valves for up to 8,000 psi. Fluid Controls, Inc, Box 186, Mentor, Ohio.

(J-88) Check Valves—Catalog, 8 pp. Shows drawings and curves for up to 5000 psi valves used with oil. Fluid Controls, Inc, Box 186, Mentor, Ohio.

(J-89) Sealless Pump —Bulletin, 4 pp. Describes in-line, completely enclosed, centrifugal pump having no shaft. Fostoria Corp, Dynapump Div, Buck & County Line Rds, Huntingdon Valley, Pa.

(J-90) Differential Pressure Manifold Valve —Brochure, 4 pp. Describes valve which uses diaphragm to control routing of fluid. Takes up to 150 psi and vacuum. Frankel Engineering Laboratories, Inc, 207 S Fifth St, Reading, Pa.

(J-91) Magnetic Separators—Brochure, 6 pp. Filter removes ferrous particles from lubricating, hydraulic and cooling liquids. Working pressure is 100 psi; capacities go up to 200 gpm. S G Frantz Co, Inc, Box 1138, Trenton 6, NJ.

(J-92) High Pressure Magnetic Separators —Brochure, 4 pp. Filter removes ferrous particles from hydraulic fluid. Working pressures go up to 5000 psi; capacities to 40 gpm. S G Frantz Co, Inc, Box 1138, Trenton 6, NJ.

(J-93) Relief Hydraulic Valves—Catalog, 15 pp. Presents flow charts and dimensions of flange and screw-type piston valves. Coolant pumps also illustrated. The Fulflo Specialties Co, Inc, 414 Fancy St, Blanchester, Ohio.

(J-94) Coolant Pumps—Catalog, 8 pp. Shows packaged machine tool coolant systems and separate gear and centrifugal pumps. Graymills Corp, 3705 N Lincoln Ave, Chicago.

(J-95) Accumulators—Brochure, 4 pp. Shows construction, sizes of, how to select bladder type hydro-pneumatic accumulator. Greer Hydraulics, Inc, 496 Grand Blvd, Westbury, NY.

(J-96) Silicone Fluids—Brochure, 8 pp. Discusses characteristics of fluids for coupling, damping, springing. Dow Corning Corp, Midland, Mich.

(J-97) Hydraulic Cylinders—Bulletin, 10 pp. Describes various configurations with bores to 12 in, operating pressure ratings to 2000 psi. Hannifin Co, Div of Parker-Hannifin Corp, 525D S Wolf Rd, Des Plaines, Ill.

(J-98) Air Valves—Bulletin, 12 pp. Explains operation, uses and characteristics of two, three and four-way valves. Includes speed control valves. Hannifin Co, Div of Parker-Hannifin Corp, 525D S Wolf Rd, Des Plaines, Ill.

(J-99) Hose Couplings—Catalog, 46 pp. Contains data on quick connective couplings of one and two way shutoff and straight through types. The Hansen Mfg Co, 4031 W 150 St, Cleveland 35.

(J-100) Quick Disconnect Couplings—Catalog, 46 pp. Shows pressure and vacuum couplings for hydraullic fluids, air, steam and other gases and liquids. Also hose clamps. The Hansen Mfg Co, 4031 W 150 St, Cleveland.

(J-101) Solenoid Valves—Brochure, 50 pp. Gives specifications and prices of two-way midget, flow-control, water and moisture-proof, and flow-switch types. Automatic Controls Div, Hays Mfg Co, 801 W 12 St, Erie, Pa.

(J-102) Double Wall Tubing—Brochure, 4 pp. Lists sizes and specifications of brazed, double wrapped steel tubing in sizes $\frac{1}{8}$ to $\frac{3}{4}$ in. OD. Avon Tube Div, Higbie Mfg Co, Fourth & Water Sts, Rochester, Mich

(J-103) Hydraulic Piston Rings—Brochure, 5 pp. Provides sample ring, specifications, tables of sizes and guides to design of piston and cylinder. Groves Piston Ring Co, Inc, 120 N Broadway, Milwaukee 2, Wisc.

(J-104) Hp Valves and Fittings—Catalog, 16 pp. Gives drawings and dimensions for 30,000 and 60,000 psi fittings. Also thermocouple adapters to 15,000 psi. High Pressure Equipment Co, 1222 Linden Ave, Erie, Pa.

(J-105) 15 Kpsi Hp Valves and Fittings—Catalog, 12 pp. Parts described use a tapered seal, are rated up to 15,000 psi. High Pressure Equipment Co, 1222 Linden Ave, Erie, Pa.

(J-106) Safety Heads—Catalog, 4 pp. Gives dimensions of heads using rupture discs. Pressures from 3,000 to 30,000 psi. High Pressure Equipment Co, 1222 Linden Ave, Erie, Pa.

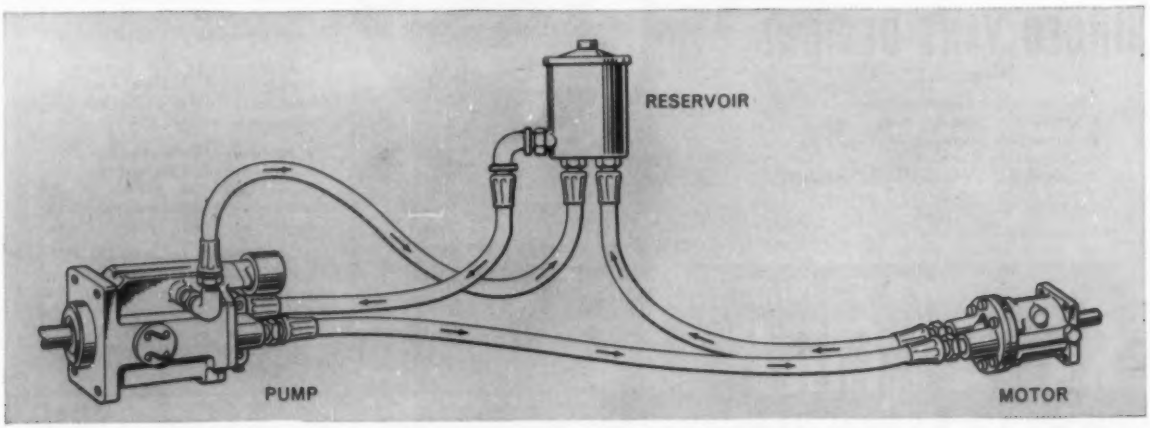
(J-107) Solenoid Valves—Bulletin, 4 pp. Provides electrical characteristics and dimensions in following sizes: $\frac{1}{8}$ in. and $\frac{1}{4}$ in. pipe or JIC tubes. Hoke Inc, Tenakill Park, Cressskill, NJ.

continued

Creative hydraulics by Sundstrand

Variable input—constant output speed transmissions designed for mobile equipment

Compact, lightweight, highly efficient hydrostatic transmissions develop up to 9 hp



32 PV Variable Displacement Pump

Reservoir 1½-Quart Capacity

7MC Fixed Displacement Motor

Here's a new idea in boosting efficiency of constant output speed auxiliary operations on mobile equipment. Compact, high-efficiency hydrostatic transmissions designed to use low-cost piston-type pumps and motors are being introduced in six standard sizes by Sundstrand—a company with more than 10 years' experience in constant speed drives.

Principal components of the Sundstrand hydrostatic transmission as shown at the left are: (1) Variable displacement axial piston pump, (2) a fixed displacement axial piston motor, and (3) a small (1½-quart) reservoir. Output horsepower depends on input speed range (see table at right).

Motor speed remains constant within ± 5% despite variations in pump input speed because of the unique control. The pump continually measures its own output and makes adjustments automatically in order to deliver a constant flow of oil.

By adding a small independent manual control to the circuit, pump delivery may be regulated to vary output speed of the motor from zero to maximum RPM. Constant motor output speed is maintained at any particular valve setting.

System is unusually compact and light in weight. There's no spilling of oil over a relief valve or bypassing of oil under pressure as pump delivers only the amount of oil needed. High efficiency is obtained —therefore there is no problem of heat dissipation.

Typical Hydrostatic Transmissions

OUTPUT H.P.	PUMP INPUT SPEED RANGE—RPM	MOTOR CONSTANT OUTPUT SPEED RPM ± 5%*
2 hp	300 to 3000	1200
3 hp	450 to 3000	1800
4 hp	600 to 2500	2400
6 hp	800 to 2400	3000
8 hp	850 to 2300	3300
9 hp	950 to 2200	3600

*Under normal rated load conditions, motor output speed can be held constant within ±5%.

Typical applications for Sundstrand hydrostatic transmissions include: Alternator drives on construction and firefighting equipment, refrigeration compressor drives, fan drives in air conditioned buses, and conveyor drives on agricultural, construction and mining equipment.

Sundstrand hydrostatic transmissions can be the answer to your power requirements. Get more facts by sending a brief outline of your needs to address below.

SUNDSTRAND

SUNDSTRAND HYDRAULICS

DIVISION OF SUNDSTRAND CORPORATION

2210 Harrison Ave., Rockford, Ill.—Eastern Sales Office: 88 Summit Ave., Summit, N. J.

AIRCRAFT AND INDUSTRIAL HYDRAULIC TRANSMISSIONS, PUMPS, MOTORS AND VALVES • OIL BURNER PUMPS • AIR SANDERS • LATHES, MILLING, BROACHING AND SPECIAL MACHINES • BROACHING TOOLS • MAGNETIC CHUCKS • PACKAGING MACHINERY

For your Vacuum and Pressure Applications . . .

Get these Exclusive Advantages of LEIMAN HINGED VANE DESIGN!

The time-tested design and quality construction of Leiman Air Pumps improve your machine operation—provide your customers with "Lifetime" durability and freedom from troubles and repairs. Proved by more than half a million installations. If your equipment now uses air pumps—if your new designs require air pumps, contact us for engineering assistance and data on Leiman Air Pumps.

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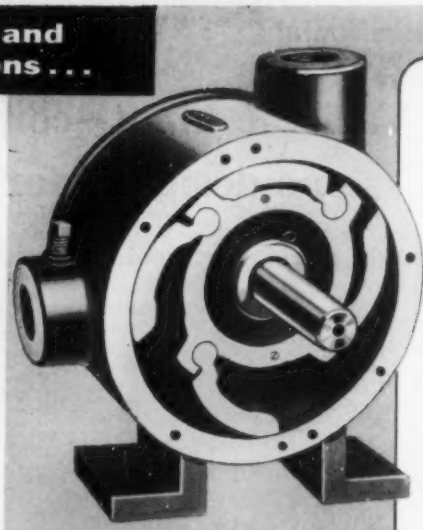
Established 1887



Wide range of types and sizes in
VACUUM to 29.9" Hg.
PRESSURE to 20 Psig.
VOLUME to 162 c.f.m.

- **Four Curved Vanes** scoop up large volumes of air. Easy-action hinges enable vanes to open and close by centrifugal force.
- **Cast Iron Vanes and Cylinders** are precision-machined, then hone themselves to hard, glassy smoothness during operation—take up their own negligible wear—assure leakproof seal and fully-rated capacity for years and years.
- **Extra-large Air Space** provides 2 to 3 times more capacity per pump, permits use of smaller pump.
- **Minimum Maintenance** because simplified design has fewer moving parts—no gaskets or packing—no composition vanes to replace.
- **Also** quiet operation—even air flow—every pump subjected to long test runs before shipment.

LEIMAN Rotary Positive AIR PUMPS

Write for new catalog showing construction, types, sizes and specifications, plus Application Book containing many "how-to-do-it" blueprints.

SEE OUR CATALOG IN SWEET'S FILE

CIRCLE 693 ON READER SERVICE CARD

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...*Leather* IMPREGNATED WITH THIOKOL, ACCRILOIDS, SILICONES, or WAX FORMULAS

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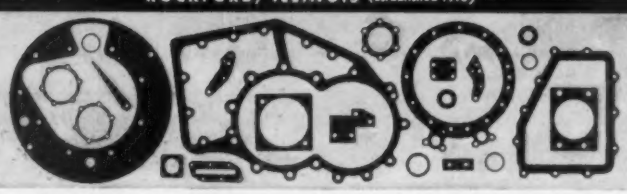
ROCKFORD, ILLINOIS (Established 1916)



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RE-USABLE
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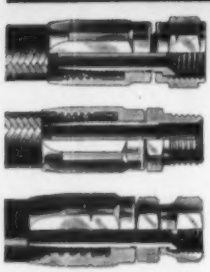

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catalogs and bulletins.....continued

(J-108) **Plug Valves**—Catalog, 32 pp. Gives sizes, pressure ratings, materials for many hand or power operated types. Homestead Valve Mfg Co, Box 348, Coraopolis, Pa.

(J-109) **Plug Valve Lubricants**—Catalog, 16 pp. Contains table to match lubricant with liquid being handled. Homestead Valve Mfg Co, Box 348, Coraopolis, Pa.

(J-110) **Synthetic Packings**—Bulletin, 4 pp. Cup packings are made of plastic resin and an elastomer. Bulletin gives sizes, operating ranges. E F Houghton & Co, 303 W Lehigh Ave, Philadelphia 33.

(J-111) **Air Control Valves**—Bulletin, 12 pp. Describes 125 psi service valves designed for limited mounting spaces. Can be used with oil or acidic water. Hunt Valve Co, 1913 E State St, Salem, Ohio.

(J-112) **Air Control Valves**—Bulletin, 12 pp. Describes 125 psi service valves which join to form manifold and are compact. Can be used with oil or acidic water. Hunt Valve Co, 1913 E State St, Salem, Ohio.

(J-113) **Solenoid Air Valve**—Bulletin, 4 pp. Shows dimensions, operating principles of pilot operated valve with quick replacement feature. Hunt Valve Co, 1913 E State St, Salem, Ohio.

(J-114) **Fluid Handling Equipment**—Bulletin, 4 pp. Describes air compressors, vacuum pumps, gear and centrifugal liquid pumps, separators, strainers, filters and others. The Kraissl Co, Inc, 299 Williams Ave, Hackensack, NJ.

(J-115) **Valve Operators**—Brochure, 8 pp. Motor and gear driven units allow operation from remote pushbutton station. Provides selection charts and tables. Hupp Aviation, Electrodyne Div, 6633 W 65 St, Chicago 38.

(J-116) **Control Valves and Cylinders**—Data folder, 14 pp. Describes multiplunger valves and telescopic cylinders. Valves have up to six plungers, four operating positions. Husco Hydraulic Unit Specialities Co, Box 257, Waukesha, Wisc.

(J-117) **Hydraulic Equipment**—Brochure, 8 pp. Describes range of sizes and capacities of gear and vane type pumps and fluid motors; directional, pressure and flow valves. Hydreco Div, The NY Air Brake Co, 9000 E Michigan, Kalamazoo, Mich.

(J-118) **Rod and Piston Packing**—Catalog, 8 pp. Gives sizes for hydraulic and pneumatic cylinder packings. There are types to handle up to 4500 psi. Hydraulic Accessories Co, 24301 Hoover Rd, Warren, Mich.

continued

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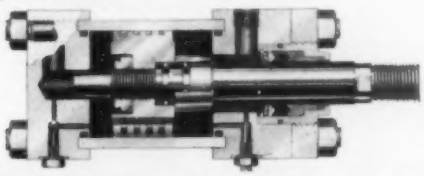
ROD SCRAPER *PLUS* ROD WIPER AS STANDARD

J. I. C. Interchangeable SQUARELINE Series features a Metal Rod Scraper *plus* a Rod Wiper in a quick change Cartridge—*Double protection* against chips, dirt, damage. Unitized cartridge rod bearing . . . easy removal and replacement . . . no cylinder disassembly necessary!



SQUARELINE 2000-3000 PSI HYDRAULIC

- 1½" to 12" bore
- 100% JIC interchangeable
- True cushion-automatic concentric alignment
- Positive piston locknut design
- Delivery from stock!

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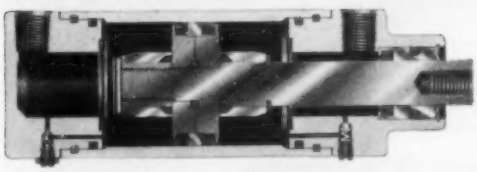
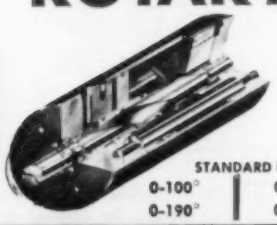
CARTER FLUID POWER

ROUNDLINE AIR-HYDRAULIC



- Space saving designs! Light weight!
- Full 1 to 1 Meehanite cartridge rod bearing.
- Precision honed heavy wall tubing—6 to 1 safety factor.
- Spring loaded "V" packing on rod end gland.
- Key type stainless steel locking ring. Allows 360° orientation of pipe ports.

ROTARY TORQUE ACTUATOR PNEUMATIC-HYDRAULIC



- New design opportunities
- To 370° rotation as standard
- Safe, powerful torque
- Air, oil, gas, water operation
- Zero leakage

STANDARD ROTATIONS

0-100° | 0-280°
0-190° | 0-370°

IMMEDIATE DELIVERY ON ALL STANDARD CYLINDERS AND ACTUATORS

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Complete bound file. Air and hydraulic cylinders. Rotaries, clamp cylinders, air valves, and the new SQUARELINE. Complete details and prices. SEND TODAY.

CARTER CONTROLS INCORPORATED

CIRCLE 537 ON READER SERVICE CARD 537

GAST ROTARY AIR MOTORS, COMPRESSORS, VACUUM PUMPS OFFER BIG ADVANTAGES AS ORIGINAL EQUIPMENT ON HUNDREDS OF PRODUCT APPLICATIONS . . .

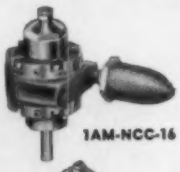
AIR MOTORS — 1/20 TO 7 H.P.

Explosion-proof Gast Air Motors give you amazing compactness and light weight for hp rating. You get the advantage of a wide range of variable speeds plus low speeds without stalling. They'll start in any position. They can't burn out from overloads. Rotor vanes take up their own wear. Simple, almost service free, Gast Rotary Air Motors "fill the bill" in many equipment applications with low first cost.

Specifications

Model No.	R.P.M.	HORSE POWER At 60 P.S.I.	HORSE POWER At 90 P.S.I.	Net Wt. Lbs.
1 AM	2,000	0.11	0.13	1½
	5,000	0.21	0.30	
2 AM	1,000	0.22	0.35	5½
	2,000	0.40	0.57	
4 AM	1,000	0.48	0.73	8
	2,000	0.78	1.10	
6 AM	1,000	0.80	1.30	17
	2,000	1.30	2.00	
8 AM	1,000	1.60	2.30	25
	2,000	2.80	4.20	
16 AM	1,000	2.70	4.20	65
	2,000	4.20	7.00	

4AM-FCC-1C



1AM-NCC-16

2AM-NCC-16

AIR COMPRESSORS — FROM .6 TO 45 C.F.M.

Integral (motor-pump) — Compact, light weight, efficient "package" units. Vanes take up their own wear. Compressor rotor mounted on motor shaft for quiet, pulseless air delivery.

Light-Duty — For intermittent service. Quick pick-up, positive displacement. Resemble heavy-duty models but without fans or deep cooling fins, not needed for brief operating periods. Simpler lubricator. (Not illustrated.)

Heavy-Duty — Fan-cooled — for long, continuous operation. Rotary design gives more air per lb., per hp. Automatic lubricator has self shut-off.

Model	Model No.	Cfm.	Rec. Max. Pressure Psi: Continuously	Rec. Max. Pressure Psi: 10 Min. On-Off	Hp.	Net Wt.* Lbs.
Integral (Motor Compressor)	0406	0.6	15	20	1/12	16
	0211	1.3	15	25	⅙	22
	0321	2.2	20	25	¼	25
	0521	3.8	15	20	⅓	26
Light-Duty	0240	2.0	10	20	¼	8
	0440	4.0	10	20	⅓	10
	0740	5.6	7	10	⅓	11
	1550	10.0	10	15	¾	29
	3040	24.2	10	15	2	68
Heavy-Duty Fan-Cooled	0465	4.0	25	30	½	18
	0765	5.6	10	15	½	18
	1065	8.3	25	30	1	34
	2065	17.0	15	20	1½	54
	2565	21.0	15	20	2	54
	4565	43.0	15	20	5	92

0211-P3A-G10X

2065-P10-G42

*Weight without base or motor, except integral models.

VACUUM PUMPS — FROM .6 TO 45 C.F.M.

Integral (motor-pump) — Compact, light weight, "packaged" units. Save mounting cost and time. Especially suited for portable equipment. Rotor mounted on motor shaft. Rotary design gives quiet operation, pulseless vacuum. Vanes take up own wear.

Light-Duty — For intermittent service. Give quick pick-up, trouble-free performance. Resemble heavy-duty models but without external fans or deep cooling fins. Simpler lubricator.

Heavy-Duty — Fan-cooled — Built for continuous service, dependability, minimum maintenance. Forced air cooling, deep cooling fins. Automatic lubricator has self shut-off.

Model	Model No.	Cfm.	Rec. Max. Vacuum, in Hg.: Continuously	Rec. Max. Vacuum, in Hg.: 10 Min. On-Off	Hp.	Net Wt.* Lbs.
Integral (Motor Pump)	0406	0.6	15	25	1/12	16
	0211	1.3	15	27	⅙	22
	0321	2.2	28		¼	27
	0521	3.8	28		⅓	28
Light-Duty	0240	2.0	15	26	¼	9
	0440	4.0	15	26	¼	11
	0740	5.6	10	26	⅓	12
	1550	10.5	15	25	½	29
	3040	24.0	15	26	1½	68
Heavy-Duty Fan-Cooled	0465	4.0	28		¼	18
	0765	5.6	28		⅓	18
	1065	8.3	28		½	34
	2065	17.0	28		1	54
	2565	21.0	28		1½	54
	4565	48.0	20	28	3	92

0406-V2-154X

2565-V12A

1550-V2A

*Weight without base or motor, except integral models.

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3040-V103

Available in 5 sizes, separate drive — 2 sizes, integral-motor.

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Gast offers you specialized experience in air motors, compressors and vacuum pumps for original equipment. Based on numerous types and sizes, over 200 different Gast models go into production each year. With the various accessories, these models have a tremendous number of applications.

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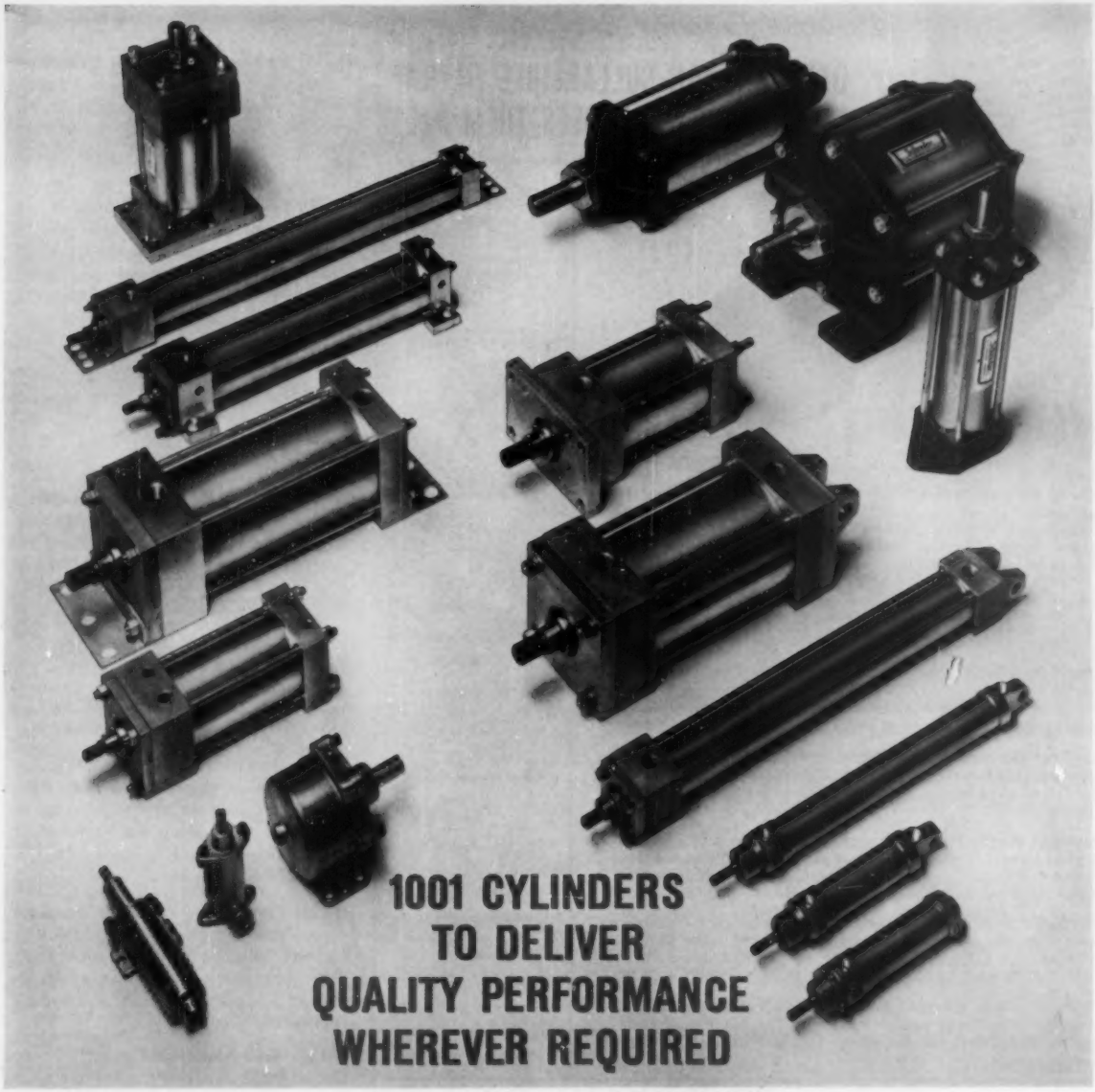
(To 7 Hp.) (To 30 Lbs.) (To 28 Inches)
GAST MANUFACTURING CORP. P.O. Box 117L, Benton Harbor, Mich.



Select from full lines to operate and control a single OEM product . . . or a plant's entire production line!

Schrader means quality . . . in complete lines of double-acting and single-acting cylinders in a variety of sizes . . . including JIC and miniature cylinders. Schrader Air Cylinders . . . as well as complete lines of Valves and Accessories . . . are at work on many OEM products and in thousands of plants performing countless jobs. Your Schrader Distributor is fully stocked . . . staffed with experts to help you solve any air circuitry problem.

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QUALITY AIR CONTROL PRODUCTS

CIRCLE 539 ON READER SERVICE CARD 539

Liquids! Gases! Solids!

DAYTON'S NON-COLLAPSIBLE, ULTRA-FLEXIBLE HOSE HANDLES THEM ALL!

Wherever low pressure or vacuum transfer is used to move liquids, gases or solids . . . wherever light unit weight and extreme flexibility must combine with high tensile strength, plus the ability to withstand abrasion and rugged use—Dayton has a non-collapsible, flexible hose to do the job or will design one to meet your specifications.

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Dayco Nylaflex* Hose is the most rugged plastic hose made. Exclusive NYLON reinforcement imparts greater flexibility, greater tensile strength and stretchability, plus longer life than ever before.

Dayflex* Current-Carrying Hose has a unique double wire construction which provides both structural strength and electrical capacity . . . carries 110-115 volts and is UL approved.

Dayflex* Plastic Hose is a proven component of extreme flexibility and high tensile strength. Adaptations are now in use for Hair Dryers, Air Conditioning, Refrigeration, Resuscitators, and Vacuum Cleaners.

Dayton Dayflex offers technical assistance to develop new uses for all its noncollapsible flexible hose. Our research and sales engineers are at your service. Fill in the coupon and mail today.

Dayflex plastic, Current-Carrying and Nylaflex hose offer innumerable design opportunities as flexible piping, venting or ductwork for industry, transportation or home.

SOME PRESENT USES

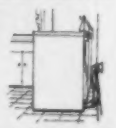
Resuscitator Oxygen Hose FDA Approved

Dayflex Current-Carrying Vacuum Hose

Flexible Hair Dryer Hose

Nylaflex Swimming Pool Hose

Industrial Vacuum Hose



Domestic Dryer Venting Hose

* *Trade Mark. Patented and Patents Pending*

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Please send free samples of flexible hose as indicated:

- ☐ Vacuum Cleaner
- ☐ Current Carrying
- ☐ Nylaflex Vacuum Cleaner
- ☐ Nylaflex Swimming Pool

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title

address

firm

city zone state

catalogs and bulletins.....continued

(J-119) **Packing Cartridges for Cylinders**—Bulletin, 8 pp. Furnishes plans and dimensions of cartridges for pneumatic or hydraulic cylinders. Pressure ratings to 1500 psi. Hydraulic Accessories Co, 24301 Hoover Rd, Warren, Mich.

(J-120) **Control Valves**—Brochure, 4 pp. Describes aircraft quality high pressure valves including solenoid operated, pressure reducing, pressure operated and other valves. Hydraulic Research & Mfg Co, 2835 N Naomi St, Burbank, Cal.

(J-121) **Aircraft Servo Valve**—Brochure 4 pp. Describes a servo valve to control hydraulic cylinders. Electrical portion, which receives input signal, is dry. Hydraulic Research & Mfg Co, 2835 N Naomi St, Burbank, Cal.

(J-122) **Aircraft Flow Control Transducer**—Brochure, 4 pp. Describes a servo valve to control hydraulic cylinders. Valve has internal feedback and a dry electrical coil. Hydraulic Research & Mfg Co, 2835 N Naomi St, Burbank, Cal.

(J-123) **Cylinders**—Bulletin, 12 pp. Provides dimensions and ratings of single and double-acting air and hydraulic cylinders for up to 5000 psi service. Hydro-Line Mfg Co, 5600 Pike Rd, Rockford, Ill.

(J-124) **General Purpose Pumps**—Catalog, 4 pp. Describes piston, flexible vane, roller pumps to deliver up to 400 psi, over 90 gpm. Also motor-pump and engine-pump combinations. Hypro Engineering, Inc, 700 39 Ave N E, Minneapolis.

(J-125) **Pump and Valve Balls**—Brochure, 8 pp. Ceramic, metal, plastic and synthetic sapphire balls are also used in bearings. Table gives size ranges and properties. Industrial Tectonics, Inc, 3684 Jackson Rd, Ann Arbor, Mich.

(J-126) **Air Motors**—Bulletin, 16 pp. Shows dimensions, construction and specifications for piston and vane types from 0.3 to 24 hp. Ingersoll-Rand Co, 11 Broadway, NYC 4.

(J127) **Cylinders**—Bulletin, 16 pp. Gives dimensions, operating characteristics for cylinders operable by air, steam, oil or water up to 750 psi. Ledeen, Inc, 3350 N Gilman Rd, El Monte, Cal.

(J-128) **Cylinders**—Bulletin, 14 pp. Provides dimensions and operating data on heavy duty cylinders rated at 200 psi for air, 500 psi hydraulic. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

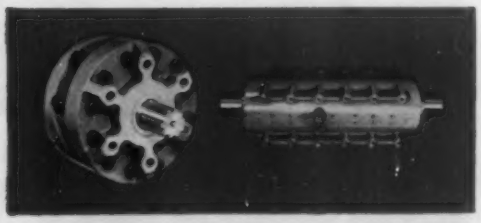
(J-129) **Small Air Cylinders**—Bulletin 4 pp. Describes single and double acting cylinders with strokes up to 4 in. at 175 psi. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

continued

ROTAC

RECIPROCATING ROTARY TORQUE ACTUATORS

for precise movement, instant torque in a compact power package!



Large illustration shows construction of Model RN (roller bearing) Rotac. Above is a journal bearing type, Model HN. The special Rotac Reciprocating Torque Actuator at right delivers 1,400,000 in./lbs. torque at 1,000 psi.

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Power available at any angle, in single or manifold installations, with shaft or body rotating in any arc to 280°.

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Power source can be air, oil, or fire-resistant fluids. Rotac can also be supplied for use with corrosive fluids.

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Power protected by patented O-ring seals. Rotac has no complex linkage, no plunger action, no external moving parts.

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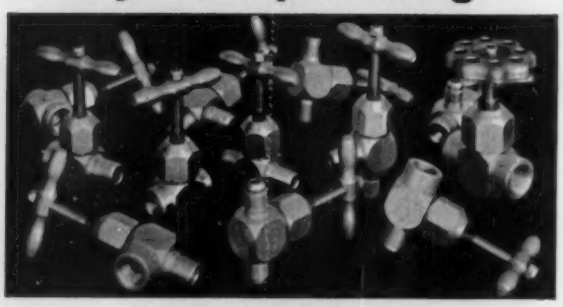
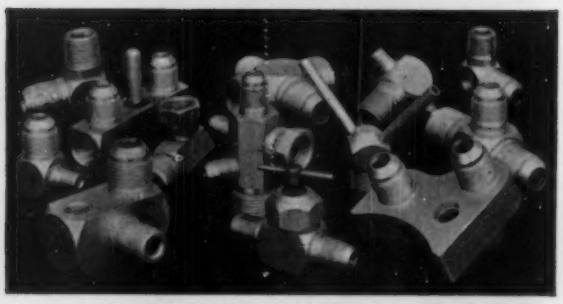


Needle Valves



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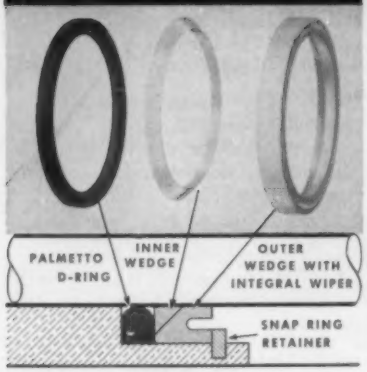

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(J-130) Air Cylinders—Bulletin 12 pp. Shows double acting cylinders with 2 to 8 in. bores, 175 psi, cushioned or non-cushioned. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

(J-131) Control Cylinders—Bulletin, 20 pp. Describes operation and uses of various configurations of cylinder-control valving packages which are air operated. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

(J-132) Checking Cylinders—Bulletin, 8 pp. Describes hydraulic cylinders used to smooth out action of pneumatic devices. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

(J-133) Air Lubricators—Bulletin, 4 pp. Explains operation of units to filter, regulate delivered air pressure, lubricate. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

(J-134) Air Control Valves—Bulletin, 10 pp. Gives dimensions, electrical data on solenoid valves for controlling air cylinders. Includes electrical accessories. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

(J-135) Back-up Washers—Brochure, 4 pp. Describes leather and elastomer combination washer used to support and protect O-rings and other packing shapes. C W Marsh Co, 22 Hudson St, Muskegon, Mich.

(J-136) Compressed Gas Driers—Brochure, 8 pp. Explains driers with and without heaters. Some can dry to —100F dewpoint or handle 5000 psi. Kahn & Co, Inc, 885 Wells Rd, Wethersfield, Conn.

(J-137) Solenoids and Solenoid Valves—Catalog, 4 pp. Gives general description of valves for aircraft, missile, ordnance and difficult environmental applications. Koontz-Wagner Electric Co, Inc, 516 N Michigan St, South Bend 1, Ind.

(J-138) Air Valves—Bulletin, 12 pp. Shows solenoid, pilot-operated control valves. Two, three and four ways valves have 300 psi, vacuum capacity. Bellows-Valvair, Div of IBEC, 230 W Market St, Akron, Ohio.

(J-139) Safety and Relief Valves—Catalog, 48 pp. Presents temperature and pressure limits, flow rates, materials, other data on valves for liquids and for gases. Kunkle Valve Co, 121 S Clinton St, Ft Wayne, Ind.

(J-140) Pressure Gages—Catalog, 48 pp. Furnishes specifications for Bourdon type gages in range from 30 in. Hg vacuum to 10,000 psi. Also accessory and calibrating equipment. Kunkle Valve Co, 121 S Clinton St, Ft Wayne, Ind.

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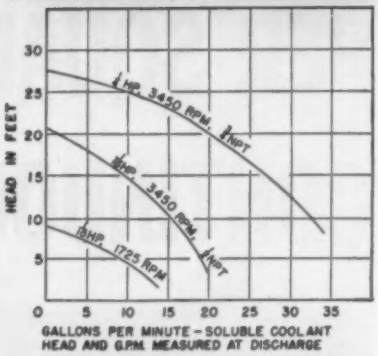

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catalogs and bulletins.....continued

(J-141) Nylon Fittings—Brochure, 4 pp. Describes tubing fittings for instrumentation, laboratory, low pressure fluids. Jaco Mfg Co, 106 First St, Berea, Ohio.

(J-142) Plugs—Catalog, 8 pp. Describes method of sealing drilled holes with grooved plug expanded by taper pin. The Lee Co, 523 Boston Post Rd, Old Saybrook, Conn.

(J-143) Plastic Valves—Brochure, 6 pp. These Y-valves resist corrosion by the chemicals listed. Sizes and other properties given. The Lunkenheimer Co, Beekman St & Waverly Ave, Cincinnati 14.

(J-144) Globe Valves—Brochure, 4 pp. Describes bronze 150 and 200 psi steam valves designed for severe service. The Lunkenheimer Co, Beekman St & Waverly Ave, Cincinnati 14.

(J-145) Air Cylinders—Catalog, 22 pp. Double-acting cylinders handle up to 200 psi air or oil, come in bores 1¼ to 10 in. Lynair, Inc, 3100 E Michigan, Jackson, Mich.

(J-146) Hydraulic Equipment—Catalog, 56 pp. Provides data on compact electrically driven power units plus cylinders, pressure switches, fittings. Oil-Dyne, Inc, 2115 W. Marquette Rd, Chicago 36.

(J-147) Sealing Rings—Brochure, 8 pp. Shows hydraulic and pneumatic rubber sealing rings with round and other cross-sections. Minnesota Rubber Co, 3630 Wooddale Ave, Minneapolis.

(J-148) Fluid Power Devices—Catalog, 72 pp. Describes hydraulic and pneumatic cylinders, valves, regulators, filters, portable pump and others. Includes dimensions and selection guides. Modernair Corp, 400 Preda St, San Leandro, Cal.

(J-149) Hose Couplings—Catalog, 8 pp. Shows couplings for one size of hose only and others that accept a range of sizes. Mulconroy Co, 54 & Jefferson Sts, Philadelphia 31.

(J-150) Compressed Air Aftercooler—Brochure, 4 pp. System cools and removes moisture from compressed air. Capacities up to 10,000 cfm. J A Murphy & Co, Inc, 1421 High St, Hamilton, Ohio.

(J-151) Compressed Air Traps—Bulletin, 4 pp. Traps remove condensate from air lines. Maximum pressure is 150 psi. Also trap heater to prevent freezing. J A Murphy & Co, Inc, 421 High St, Hamilton, Ohio.

(J-152) Pneumatic Products—Catalog, 81 pp. Describes filters, pressure regulators, lubricators, and valves, spray guns. C A Norgren Co, 3400 S Elati St, Englewood, Col.

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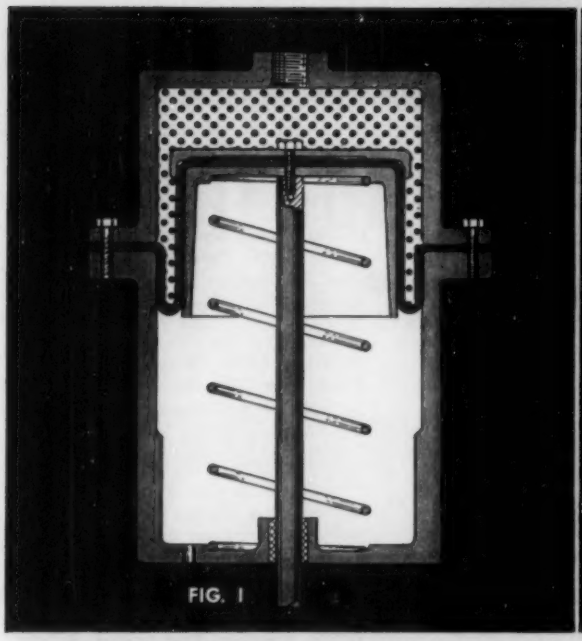
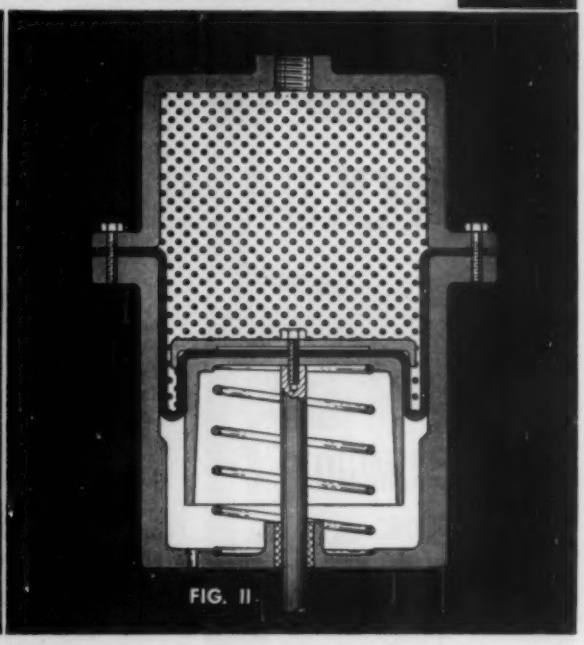


FIG. I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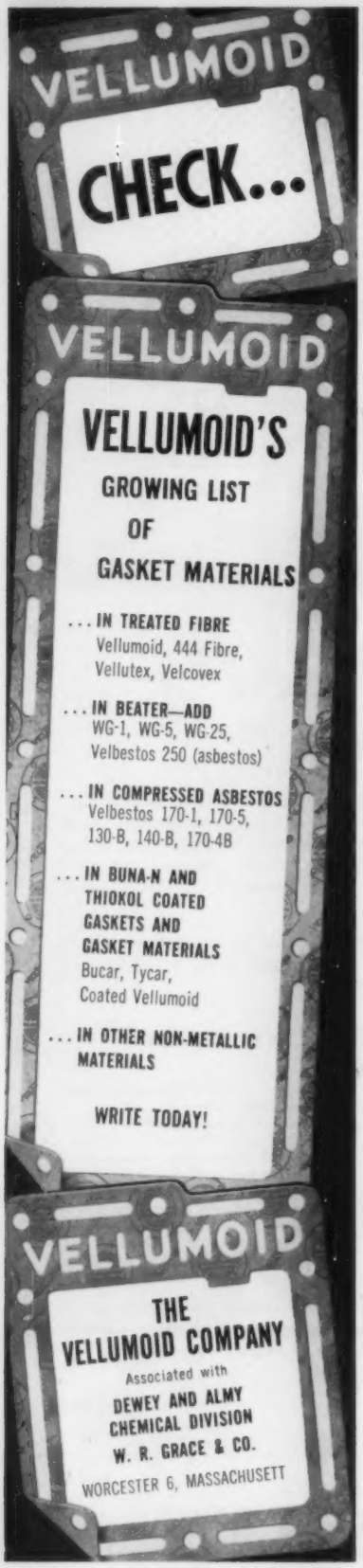

catalogs and bulletins.....continued

(J-153) **Air Control Valves**—Catalog, 112 pp. Describes four-, three- and two-way valves which are solenoid, pilot and manually operated. Also manifolds and other accessories. Numatics, Inc, Highland, Mich.

(J-154) **Temperature Control Valves**—Catalog, 8 pp. Sliding-gate valve is used for steam, water, air, oil, gas or chemicals. Also combination pressure and temperature regulators. OPW-Jordan Corp, 6013 Wiehe Rd, Cincinnati 13.

(J-155) **Blowers**—Catalog, 4 pp. Ventilation and cooling blowers are driven by electric motors up to 2 hp. Tables give dimensions and performance. Peerless Electric Div, H K Porter Co, Inc, 1401 W Market St, Warren, Ohio.

(J-156) **Miniature Hydraulics Systems**—Catalog, 12 pp. Describes small package of pump, motor, valves, cylinder. For up to 5000 psi peaks. Oil-dyne, Inc, 2115 W. Marquette Rd, Chicago 36.

(J-157) **Hydraulic Equipment**—Catalog, 16 pp. Describes industrial size pumps, constant torque drives, cylinders, valves and associated equipment. The Oilgear Co, 1560 W Pierce St, Milwaukee, Wisc.

(J-158) **Lubrication Equipment**—Catalog, 34 pp. Describes oil cups, oiling systems, dispensers, valves, flow indicators, sight gages, filters and chain oilers. Oil-Rite Corp, 2382 Waldo Blvd, Manitowoc, Wisc.

(J-159) **Adjustable Stroke Cylinders**—Bulletin, 4 pp. Shows construction, dimensions of cylinders with 1½ to 8 in. bores. Ortman-Miller Machine Co, Inc, 19 143 St, Hammond, Ind.

(J-160) **Flexible Metal Hose, Tubing and Fittings**—Catalog, 12 pp. Presents dimensional standards, strengths, applications and physical properties of components and stock assemblies. Packless Metal Hose, Inc, 730 S Columbus Ave, Mount Vernon, NY.

(J-161) **Hose**—Catalog, 8 pp. Describes hose and hose fittings for air, water, oil and fuel to 250 psi. Parker Fittings & Hose Div of Parker-Hannifin Corp, 17325 Euclid Ave, Cleveland 12.

(J-162) **Electro-hydraulic Servo Valves**—Three bulletins, 12 pp. Give performance curves, specifications and dimensions of two industrial and one missile and aircraft valves. Pegasus Laboratories, Inc, 3690 W Eleven Mile Rd, Berkley, Mich.

(J-163) **Hydraulic Actuator**—Bulletin, 4 pp. Ram has provisions for mounting servo valve and position feedback potentiometer. Strokes up to 10 in., operating pressure 3000 psi. Pegasus Laboratories, Inc, 3690 W Eleven Mile Rd, Berkley, Mich.

(J-164) **Flexible Metal Hose**—Catalog, 36 pp. Describes hose for handling oil, steam, diesel and air exhaust, materials, other fluids. Also rivet conveyors and automatic barrel fillers. Pennsylvania Flexible Metallic Tubing Co, Paoli, Pa.

(J-165) **Air and Hydraulic Cylinders**—Brochure, 8 pp. Describes, illustrates and gives specifications for cylinders and accessories. Petch Mfg Co, Box 456, Alpena, Mich.

(J-166) **Hydraulic Panels**—Bulletin, 8 pp. Describes building block type of panel for hydraulic valve mounting. Petch Mfg Co, Box 456, Alpena, Mich.

(J-167) **Control Valves**—Brochure, 8 pp. Presents sampling of hydraulic, pneumatic and cryogenic control valves for airborne and ground support applications in the missile and aircraft industry. Pneu-Hydro Valve Corp, 52 Horse Hill Rd, Cedar Knolls, NJ.

(J-168) **Aluminum Pipe Fittings**—Bulletin, 4 pp. Presents sizes, uses, advantages of corrosion resistant fittings. Forge & Fittings Div, H K Porter Co, Inc, Box 95, Roselle, NJ.

(J-169) **Branch Connection Fittings**—Catalog, 6 pp. Shows weld fittings that replace regular tees. For ⅛ to 1½ in. branches. Forge & Fittings Div, H K Porter Co, Inc, Box 95, Roselle, NJ.

(J-170) **Pipe Fittings**—Catalog, 32 pp. Provides data on forged stainless, alloy and carbon steel screw-end and socket-weld fittings, sizes ⅛ to 4 in. Forge & Fittings Div, H K Porter Co, Inc, Box 95, Roselle, NJ.

(J-171) **Hydraulic Pumps**—Three brochures, 12 pp. Provide performance curves, dimensional drawings and construction details for variable delivery pumps rated for 300 psi. Three sizes are: 18, 50 and 200 gpm. Texas Hydraulics, Inc, 8500 Research Blvd, Austin 5, Texas.

(J-172) **Water Temperature Regulators**—Data sheets, 8 pp. Shows domestic and process regulators for mixing hot and cold water or steam and water. The Powers Regulator Co, 3490 Oakton St, Skokie, Ill.

(J-173) **Diaphragm Control Valves**—Data sheets, 16 pp. Shows sizes, capacities and sample systems for air or water operated valves controlling steam, hot or cold water. The Powers Regulator Co, 3490 Oakton St, Skokie, Ill.

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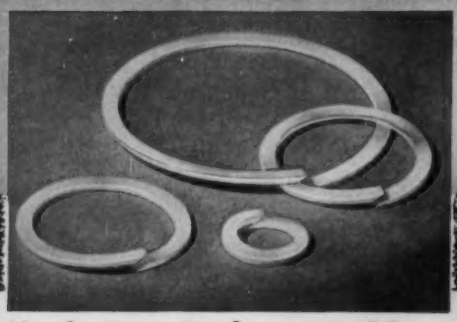

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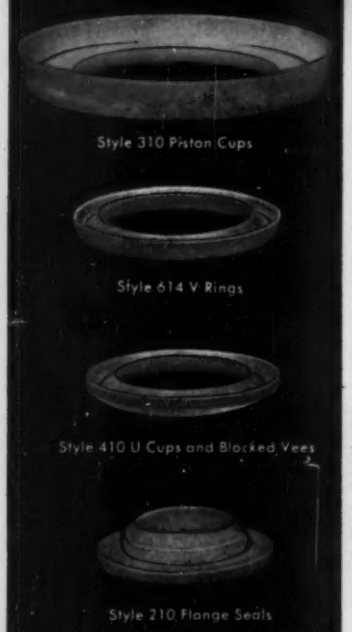

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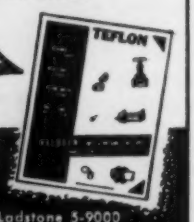

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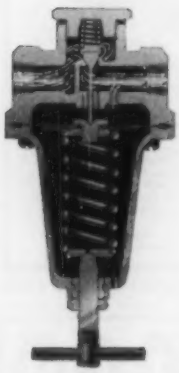
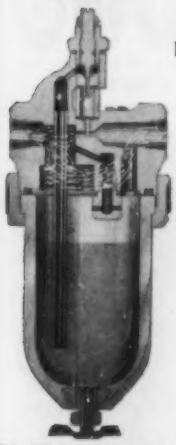
Exclusive tornado action spirals dirt and moisture downward to "quiet zone". Smaller particles are filtered out by porous bronze cone.



REGULATOR
Exclusive aspirator action provides greater air flow with minimum pressure drop. Aspirator acts directly on diaphragm for precise control, steady pressure.



LUBRICATOR
Exclusive high velocity venturi section for efficient atomization at air flow rates as low as 1 CFM. Automatic bypass valve maintains lubrication at high rates. Automatic fill available to eliminate downtime and maintenance.

This Watts combination assures the continuous supply of clean dry air, at a constant pressure, with just the right amount of lubrication at points of friction and wear, that pneumatic equipment requires today.

You get **high efficiency** from the Watts line of advanced-design air line filters, regulators, and "Perma Fog" lubricators. It's the **quality** assembly. Complete range of sizes: ¼", ⅜", ½", ¾", 1". Write for more information.

WATTS REGULATOR CO.
Lawrence, Massachusetts, U.S.A.
Specialists in protection and control devices since 1875

catalogs and bulletins.....continued

(J-175) **Air Compressors**—Brochure, 12 pp. Describes base and tank mounted air cooled compressors for up to 500 psi output. Quincy Compressor Co, 217 Main St, Quincy, Ill.

(J-176) **Hydraulic Tubing**—Brochure, 16 pp. Shows manufacture and use of resistance welded, low carbon steel tubing. Discusses compliance with several sets of standards. Republic Steel Corp, Steel & Tubes Div, 224 E 131 St, Cleveland 8.

(J-177) **Cylinder Tubing**—Brochure, 8 pp. Discusses properties, sizes, manufacturing of resistance welded tubing. Republic Steel Corp, Steel & Tubes Div, 224 E 131 St, Cleveland 8.

(J-178) **Corrosion Proof Pipe and Fittings**—Brochure, 6 pp. Schedule 40 pipe is seamless steel. Steel or ductile iron fittings are rated for 150 psi. Both are lined with teflon. Resistoflex Corp, Woodland Rd, Roseland, NJ.

(J-179) **Chemically Resistant Hose**—Brochure, 12 pp. Hose and hose assemblies are lined with teflon. Hose and fitting sizes, pressure ratings given. Also gives table of chemical resistance ratings. Resistoflex Corp, Woodland Rd, Roseland, NJ.

(J-180) **Corrosion Proof Piping Bellows**—Brochure, 4 pp. Presents pressure and temperature ratings plus dimensions of molded teflon bellows. Resistoflex Corp, Woodland Rd, Roseland, NJ.

(J-181) **Chemical Transfer Hose**—Brochure, 4 pp. Teflon lined hose takes pressures up to 150 psi. Construction and dimensions of hose and fittings are shown. Resistoflex Corp, Woodland Rd, Roseland, NJ.

(J-182) **Plastic Pumps, Valves**—Catalog, 101 pp. Contains engineering data, maintenance instructions, drawings of pumps rated to 40 gpm. Includes corrosion resistant pipe, valves and fittings. Vanton Pump & Equipment Corp, Div of Cooper Alloy Corp, Bloy St, Hillside, NJ.

(J-183) **Motor-blowers**—Brochure, 6 pp. Blower units have capacities from 4 to 150 cfm. Units are designed for compactness. Also come less motor. Ripley Co, Inc, Box 31, Middeltown, Conn.

(J-184) **Air Valves**—Catalog, 18 pp. Gives sizes, operation, construction of solenoid, air mechanically operated valves. Ross Operating Valve Co, 120 E Golden Gate, Detroit 3.

(J-185) **Solenoid Air Valves**—Bulletin, 7 pp. Shows use of model as pilot head or valve. Designed for compactness, fast operation. Ross Operating Valve Co, 120 E Golden Gate, Detroit 3.

continued

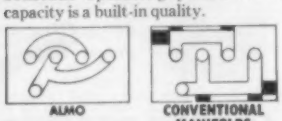
LET'S TALK MANIFOLD FACTS!

The advantages of (Almo) manifolds as opposed to other manifolds are many. Their unique design offers complete flexibility in the mounting of take-offs and valves. Thus an Almo manifold is more adaptable to your requirements. Here are 3 features that definitely effect performance, weight and size.

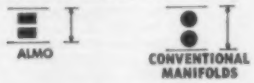
ALMO* **HYDRAULIC MANIFOLDS**

1. Flow lines are short as possible with no corners or sharp recesses to collect dirt and obstruct flow.

2. Method of construction permits better utilization of area, smaller overall dimensions and fewer complications while maintaining correct channel dimensions and constant operating pressures. PSI capacity is a built-in quality.



3. Rectangular cross section of flow lines makes possible thinner overall construction and less weight than in comparable manifolds.



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*THE UNIQUE FLUID CIRCUIT

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MANIFOLD & TOOL CO.
11472 KALTZ / CENTERLINE, MICH.

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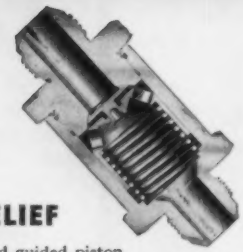
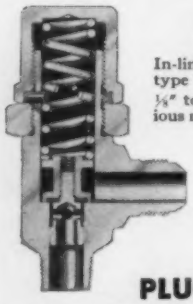
INDUSTRIAL • CHEMICAL • AIRCRAFT

CHECK

Quality Check Valves of several types—ball, poppet, Hy-pressure, Free-flow—all metals, various portings, and pressures up to 5000 psi. Pipe and tube sizes up to 2".



RELIEF



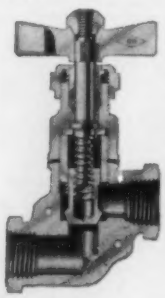
In-line and guided piston type Relief Valves. Metal or rubber seal. ⅛" to ¾" pipe or tube connections. Various metals. Many settings to 2750 psi.

Also Pilot-operated type, with quick unloading and silent operation, ¼" to 2" to 5000 psi. Remote control pilot available.

PLUG

Precision-made Plug Valves for wide general use in brass, aluminum alloy, or stainless steel, ⅛" to 1". +32° to 160°F. With Teflon plug, −65° to 250°F, without lubrication. Aluminum alloy or stainless steel.

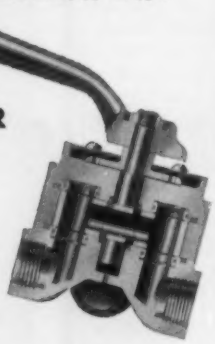
GLOBE AND NEEDLE



Super duty shut-off valves, angle and offset, for up to 5000 psi service, ⅛" to 2", with mounting holes, and panel mounting brackets. Also high pressure Needle Valves for 10,000 psi. working pressure—proofed at 25,000 psi. One piece, stainless steel, ⅛" to ½".

LO-TORQ SELECTOR

Directional flow control for service up to 6000 psi. Balancing principle uses line pressure to make turning easy with short handle. 2, 3, 4-way, with various drillings. Side, bottom, and sub-plate porting. Panel mounting. ⅛" to 2".



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Distributors in principal cities coast to coast.

RM REPUBLIC MANUFACTURING CO.

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Saves hours in piping installations

PAT. PENDING

Eliminates leaks in oil, air, water, vacuum, chemical lines

Tru-Seal saves hours in assembling piping installations because it enables you to run your pipe line, in any direction you wish, quickly and easily—without having to recut and re-thread piping sections. Wherever used on air, oil, water, steam, vacuum or chemical lines, it seals perfectly at —100° F. to plus 500° F.—*without the use of pipe dope.* Its installation requires only light tightening torque, thus eliminating over-tightening damage to valves, pumps, compressors, and other fittings.

For further information write

TRU-SEAL DIVISION
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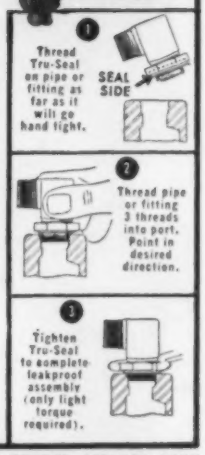
"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.


1
Thread Tru-Seal on pipe or fitting as far as it will go hand tight.
SEAL SIDE
2
Thread pipe or fitting 3 threads into port. Point in desired direction.
3
Tighten Tru-Seal to complete leakproof assembly (only light torque required).

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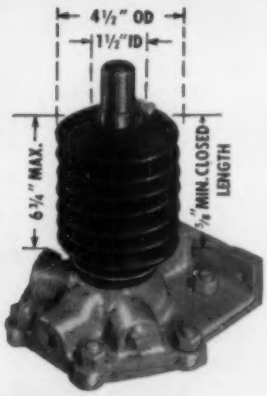
GORTITE (new neoprene)

SLEEVES

BOOTS



Ask for new bulletin AH-3, describing applications for hydraulic cylinders, jacks, rams, etc.

A&A MFG. COMPANY, Inc.

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BELLOWS—BOOTS—SLEEVES—WAY-PROTECTORS

CIRCLE 701 ON READER SERVICE CARD

catalogs and bulletins.....continued

(J-186) **Pressure Boosters**—Catalog, 14 pp. Many charts and tables describe hydraulic tanks, and boosters which convert 80 psi air up to 300 psi hydraulic pressure. The S-P Mfg Corp, 30201 Aurora Rd, Cleveland 39.

(J-187) **Valves and Cylinders**—Catalog, 12 pp. Drawings and tables detail control valves and up to 14 in. bore cylinders for up to 500 psi. The S-P Mfg Corp, 30201 Aurora Rd, Cleveland 39.

(J-188) **Hydraulic Cylinders**—Catalog, 12 pp. Provides dimensions for a series of 2000 psi cylinders. Includes tables and charts of pressure and flow data plus other design information. The S-P Mfg Corp, 30201 Aurora Rd, Cleveland 39.

(J-189) **Electro-hydraulic Servo Valves**—Brochure, 36 pp. Presents performance curves and specifications for valves in four ranges from 0 to 150 gpm. Handle supply pressures up to 300 psi. Sanders Associates, Inc, 95 Canal St, Nashua, NH.

(J-190) **Tube Pumps**—Brochure, 8 pp. Describes pump which does not contact fluid. Shows straight through, multitube types. Sigmamotor, Inc, 3 N Main St, Middleport, NY.

(J-191) **Air Compressor**—Bulletin, 12 pp. Presents dimensions and ratings for motor driven, one and two stage compressors with ratings to 250 psi. Worthington Corp, Harrison, NJ.

(J-192) **Fuel Gage Systems**—Brochure, 6 pp. Shows components and systems for measuring and managing fuel, oil, liquid oxygen and other liquids in aircraft. Simmonds Aerocessories, Inc, 105 White Plains Rd, Tarrytown, NY.

(J-193) **Hydraulic Power Units**—Brochure, 9 pp. Gives brief specifications of combination pump, reservoir, ac or dc motors or gasoline engine, and valves. Capacities to 25 gpm. Spencer Hydraulics, Inc, 2607 Eaton Lane, Racine, Wisc.

(J-194) **Sealing Gaskets**—Brochure, 8 pp. Rubber seals are molded into metal gaskets. Standard gaskets are for MS fittings. Special designs are shown. Stillman Rubber Co, 5813 Marilyn Ave, Culver City, Cal.

(J-195) **Silicone Rubber O-rings**—Brochure, 10 pp. Lists sizes, materials, cross-reference part numbers—MS, AN, Ordnance. Stillman Rubber Co, 5813 Marilyn Ave, Culver City, Cal.

(J-196) **Hydraulic Steel Tubing**—Brochure, 4 pp. Provides table of sizes and working pressures. Summerill Tubing Co, Div of Columbia Steel & Shafting Co, Box 1557, Pittsburgh 30.

continued

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Air and Hydraulic Cylinders from 50 to 5000 P.S.I.

WELDED FLANGE AND SPECIAL CYLINDERS

Model E Class M

Class M: Heavy steel tubing with welded flange construction eliminates tie rods. Available in all mountings, up to 16" bore. For all types of heavy duty applications, air, oil or water, at pressures to 650 P.S.I.

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LOCK-RING FLANGE, HIGH PRESSURE HYDRAULIC CYLINDERS

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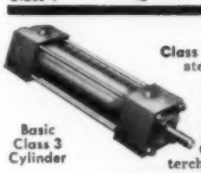
Class 4: Fabricated from heavy-wall, honed steel tubing. Rugged construction — no tie rods. Choice of cushioned or non-cushioned heads; 5 standard mountings, pressures to 4,000 P.S.I.

Model C Class 4

SQUARE HEAD, TIE-ROD CYLINDERS



Basic Class 3 Cylinder

Class 3: Square head, steel plate, honed steel tubing and tie-rod construction. Choice of cushioned or non-cushioned heads. 18 standard mountings. Completely J.I.C. Interchangeable with other square head hydraulic cylinders. Pressures to 3,000 P.S.I.

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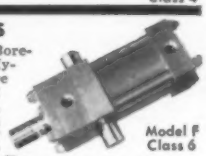
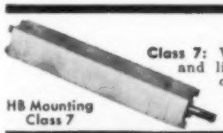


Model F Class 6

SQUARE BARREL CYLINDERS



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Class 7: World's First! Unmatched appearance, durability and light weight. Clean-lined, flush, four-square design; no tie-rods, no complex head locks. Widest range of interchangeable mountings. The most versatile air and hydraulic cylinder.

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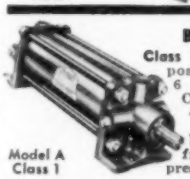
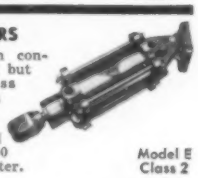


Model A Class 1

Class 1: Self-sealing composition cup packings. 6 standard mountings. Choice of adjustable cushion, self-regulating or non-cushion heads. Diameters from 1½" to 16". For pressures to 250 P.S.I.

Class 2: Similar in construction to Class 1, but cylinder wall (brass tubing) recessed and gasketed into Iron Alloy cylinder heads. Recommended for pressures to 500 P.S.I., air, oil or water.



Model E Class 2

During the past 30 years, NOPAK Class 1 and 2 cylinders earned their reputation as "The most cylinder for the least money."

NOPAK VALVES *for precision control of fluid power*

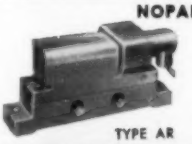
NOPAK-MATIC POPPET-TYPE, PILOT-OPERATED VALVES

Series 310 2- or 3-Way

Fast acting, high volume air valves in pipe sizes from ¼" to 1¼" with master (air piloted) single or double solenoid. Mounting choice: Side or bottom ported sub-plates or manifolds. No valve seats machined in valve body. Removing cover plates affords easy access to piston poppets housed within removable, interchangeable cartridges. 100% J.I.C. Easily modified for vacuum operation.

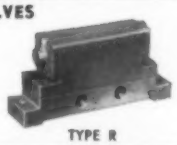
Series 420 4-Way

NOPAK MODEL "V" PILOT OR SOLENOID VALVES



TYPE AR

These small, compact, low-priced, 3- and 4-way valves are furnished in two basic cycles: Type AR (air return) always returns to initial position when solenoid is de-energized or pilot exhausted. Type R remains positioned as last energized until opposite solenoid or pilot is actuated. For full description ask for Bulletin "V".

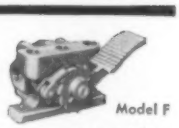


TYPE R

NOPAK ROTATING DISC VALVES

3- and 4-Way Hand Valve

The original NOPAK Valves, available in 2-, 3-, 4-way, and many special cycles, for control of cylinders to 500 P.S.I., air or hydraulic. Precision lapped rotating disc and body seat are always protected from pressure flow or exhaust. These low-priced valves with their simple, rugged, packless construction have never been equalled for durability.



Model F

3- and 4-Way Foot Valve

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VALVES and CYLINDERS

GALLAND-HENNING NOPAK DIVISION

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9500 Series

MINIATURE LEAKPROOF SHUTOFF VALVE

LEAKPROOFMANSHIP...a word not found in Webster's but coined to convey our philosophy (and we live up to it, too) of perfect leakproof sealing. Not merely braggadocio but an operational certainty. It is said that the very best things come in small packages and this is especially true of the Circle Seal 9500 Series Valves. Miniaturized at no sacrifice in quality, these valves operate from 0-2000 psi while maintaining all the features that have made the name CIRCLE SEAL synonymous with valve quality.

- Leakproof in vacuum or pressure service
- Straight through flow
- Positive position indication
- Provides accurate metering
- Effortless opening and closing
- "O" Ring seals virtually eliminate wear
- Convenient 90° "T" handle

CIRCLE SEAL PRODUCTS COMPANY, INC.
2181 East Foothill Boulevard • Pasadena, California

precision valves

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If you use gauges you need a CHEMIQUIP PRESSURE SNUBBER

Now! CHEMIQUIP, THE ORIGINAL. GIVES YOU TYPE 316 POROUS DISCS, EXCLUSIVELY

What they do: Chemiquip pressure snubbers give steady average pressure reading—smooth out pressure impulses and fluctuations—eliminate pressure gauge failure due to shock—remove harmful solids from actuating fluids. Available in ⅛", ¼" and ½" NPT.

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- RESISTS CORROSION
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Pneumatic Coupling Series –
For shop air line applications

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CIRCLE 703 ON READER SERVICE CARD

catalogs and bulletins.....continued

(J-197) Centrifugal Pumps—Catalog, 36 pp. Presents selection method, performance curves, dimensions and optional equipment for close coupled and base mounted types. Taco Heaters, Inc, 1160 Cranston St, Cranston, RI.

(J-198) Gaskets and Packing—Catalog, 23 pp. Presents materials properties, service recommendations, gasket design tips. Rhopac, Inc, 3425 Cleveland, Skokie, Ill.

(J-199) Gas Pressure Regulator—Brochure, 4 pp. Regulator gives controlled downstream pressures from 25 to 100 psig, and are missile qualified. Response curves given. Thiokol Chemical Corp, Reaction Motors Div, Ford Rd, Denville, NJ.

(J-200) Metered Lubrication—Bulletin, 6 pp. Explains circulating oil lubrication system and control and malfunction indication features. Trabon Engineering Corp, 28815 Aurora Rd, Solon, Ohio.

(J-201) Metallic O-rings—Bulletin, 32 pp. Three different types, standard, pressurized and vented, are available plated or coated. Bulletin gives sizes and explains how to design for metallic o-rings. United Aircraft Products, Inc, Box 1035, Dayton, Ohio.

(J-202) Flexible Metal Hose—Catalog, 20 pp. Shows types for high temperatures and pressures as well as conveyor hose and tubing for blowers and exhaust gases. Universal Metal Hose Co, 2133 S Kedzie Ave, Chicago 23.

(J-203) Solenoid Valves—Catalog, 16 pp. Valves designed for corrosion service. Has table for choosing valve material to fit chemical. Operating pressures to 130 psi. Valcor Engineering Corp, 365 Carnegie Ave, Kenilworth, NJ.

(J-204) Flexible Air Ducting—Brochure, 4 pp. Metal and fabric ducting is used for air conditioning, ventilation, chemical and corrosive fumes. Sizes go from 1½ to 12 in. ID. The Wiremold Co, Hartford 10, Conn.

(J-205) Control Valves—Catalog, 16 pp. Gives dimensions, specifications of valves and auxiliary devices for controlling air, oil or water. Versa Products Co, Inc, 150 Coolidge Ave, Englewood, NJ.

(J-206) Gaskets, Packing and Washers—Catalog, 32 pp. Describes sheet material and made up parts for general automotive and aircraft use. Also industrial gaskets and washers. Victor Mfg & Gasket Co, 5750 Roosevelt Rd, Chicago.

(J-207) Rotary Pumps—Catalog, 8 pp. Illustrates operating principles, dimensions, specifications, materials available for ratings from ¼ to 300 gpm. Viking Pump Co, Fourth & State, Cedar Falls, Iowa.

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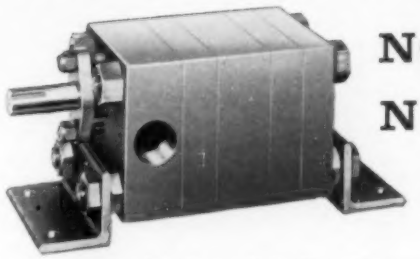

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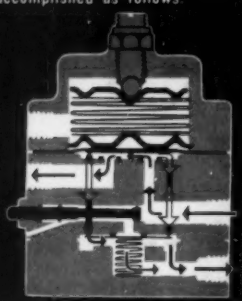

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